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BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

No. 51

ELECTRONICS

The Maplin Magazine

MARCH 1992 £1.60



Build this superb
Valve Amplifier
and give your
ears a treat!

- * **Transmit video signals without cables**
 - * **Aircraft communication systems explained**
 - * **Discover the secret of artificial intelligence**
 - * **How computers are benefiting the designer**
- PLUS!** How to... Build an AGC microphone pre-amp and a 'Peep' alarm, Win an all expenses paid trip to the Goonhilly satellite earth station, and lots, lots more!

Low Cost Video
Processing Unit,
See inside ...



EDITORIAL

■ Hello again! and welcome to this month's edition of 'Electronics'. In response to the many letters that have been received over the past few months, suggesting that more Hi-Fi and video related projects are featured, I am happy to say that there are two such projects in this issue. Alan Williamson introduces the superb Velleman Hi-Fi Stereo Valve Amplifier, as featured on the front cover. As well as describing circuit operation, he also gives the amplifier a full road-test; comparing the amplifier with the veritable Ferrari's of the Hi-Fi world. How did the amplifier fare? Well, you'll just have to read the article to find out! Also featured (indirectly) on the front cover is the Video Box project – an ingenious unit that, for little more than the price of a few good quality video cassette tapes, allows the video enthusiast to make their productions more professional. The main use for the unit is as a video fader, but the unit also provides many other facilities such as signal inversion, sync stripping and regeneration, and colour burst removal. The unit is an ideal video 'building block' as it can provide various control and synchronisation signals. Oh dear, it seems that I have run out of space again, so until next month, all that remains for me to say, is that I hope you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

R. Ball

ABC 33,837

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PROJECTS

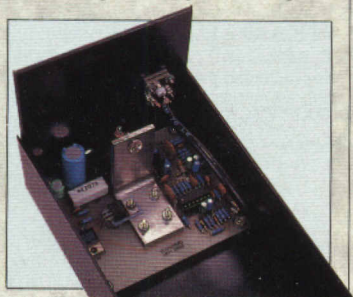
8 HI-FI STEREO VALVE AMPLIFIER

■ A superb Hi-Fi amplifier that sounds as good as it looks!



16 INFRA-RED VIDEO LINK

■ Enables wireless transmission of video signals using infra-red light.

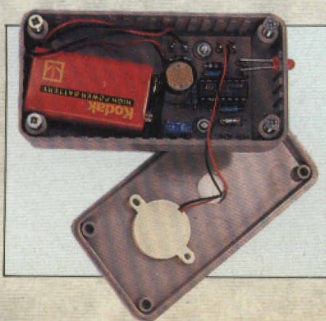


32 FUNTRONICS: LIGHT/DARK INDICATOR

■ Part four of this beginners' series presents a simple light level indicator.

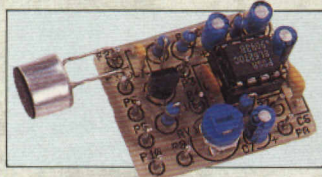
48 'PEEP' ALARM

■ A compact, low-power alarm unit that is light level triggered.



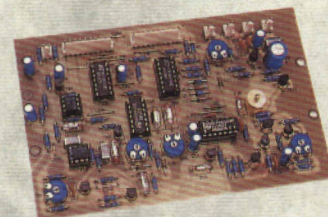
56 DATA FILE: AGC MIC. PREAMP

■ Application circuit for the versatile SL6270 VOGAD IC.



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■ A low cost, high quality video fader and signal processing unit with numerous facilities.



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■ The concluding part in this series about the mathematics behind digital electronics.

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Prices shown in this issue include VAT at 17.5% (except items marked NV which are rated at 0%) and are valid between 7th February 1992 and 30th April 1992

NEWS Report



Keeping it Small

Soon the computer industry will have to start issuing a magnifying glass with every new model sold. Computers now come gift-wrapped as portables, laptops, pockets, and now, notebook-sized. Mobile computing is rapidly becoming a must for the mobile society of the '90s, says Toshiba, the company responsible for making the laptop a household word, who are convinced that the advantages of mobile computing are already making immobile desktop computers obsolete.

Now Toshiba is gunning for the notebook computer market – already the company has a near 40% market-share. Toshiba's newest offering is the 486SX-based notebook PC which, apart from boasting faster computing speeds than any other notebook PC, gives users a choice of gas plasma or LCD screens. Meanwhile Apple Computers have launched Macintosh PowerBook, a series of trend-setting, notebook-sized, computers priced from \$2,300. Also new is the Advanced

Notebook from Dell Computer, which offers longer battery life and increased memory and storage capacity. The entry price for 4Mb RAM and 60Mb hard disk is £2,099.

More for less computer power is also revealed by Psion of Organiser fame. The company has announced a new generation of 16-bit pocket computers. Designed to put computer resources and personal productivity into everyone's hands (literally), the new Series 3 range telescopes desktop computing power into a slim pocket-sized case weighing just 265g, measuring just 6.5 x 3.3 x 0.9in., and priced from under £200 including VAT.

Last but certainly not least is the ultimate computer companion in the form of the newly launched PC-3000 palmtop computer from Sharp. An IBM PC compatible with in-built personal information management software, the unit is smaller than a standard video cassette and weighs little more than 1lb including batteries.

First UK Hold DJ Now on Air

WordPerfect, a leading word-processing software supplier, has become the first company in the UK to go live with a 'hold jockey' telephone answering system. A 'hold jockey' is a professional DJ who broadcasts down the telephone lines keeping callers who are on hold for a phone-in informed and entertained while they are waiting for a customer support operator. No more short blasts of 'The Sound of Music' for callers, they are more likely to hear a selection of music, technical tips, traffic reports on waiting time, commercials on WordPerfect products(!) plus info on special offers.

The company has installed a sound-proofed studio at its head office in Surrey, equipped with microphones, mixing board and compact disc player, as well as a large selection of music covering a wide variety of types, such as soft rock, jazz and rhythm and

blues. They are also installing a real-time, real person – a David Wright – to let callers know how long they will have to continue to hold, and to decide whether to wait or call back at a later and less busy time. Or, of course, the company could just employ a few more customer support personnel.

Laser Light

A report in the Wall Street Journal confirms that separate teams at IBM and Spire Corporation have succeeded in making Porous Silicon to emit light by stimulating it electrically. It is expected that this will lead to the creation of opto-electronic devices which will convert electrical signals into light, which could be incorporated into speed-critical interconnections in computers. However, Porous Silicon junctions will probably have to be encapsulated, because the optical property fades when they are exposed to light!

Paging the World

A recent report from Swedish Telecom suggests that the number of paging subscribers in Europe will rise from the present level of one million to an impressive 13 million by the year 2000. The PTT states the increase is being triggered by the advent of compatible European standards together with the harmonisation of charging and marketing programmes. At the same time, Swedish Telecom see alphanumeric paging becoming an extension of the PABX systems.

Ofitel Puts in the Boot

Professor Sir Bryan Carsberg, the increasingly officious boss of Ofitel, is putting the boot into BT over the matter of supplying unfair cross-subsidised apparatus. Ofitel is calling for detailed budgets which, if not forthcoming, will result in the situation being reviewed. For the user however, Ofitel's move could be bad news, the most likely effect of which being that of putting up the cost of basic telephone equipment. The next Ofitel activity could be that of following the French Telecomms Ministry in the act of conducting office to office searches for non-approved terminals! The French law however, forbids searches on private premises.

High Flyers

British Airways are making it possible for travellers flying into Terminal 1 at Heathrow to hire a mobile phone from Vodafone, presumably to allow late arrival passengers to phone home. However, Singapore Airlines is going one better by providing passengers with a Skyphone service on its fleet of 50 long-haul aircraft. SIA is the first commercial airline to sign an agreement for Skyphone, which uses the Inmarsat satellite network to provide international air to ground and even air to air communications. As if the Singapore Girls do not provide sufficient distraction!

Battery Power

Developments in battery technology are proceeding apace – so much so that a practical electrically-driven car may not be so far away. The latest state-of-the-art, aluminium-air technology, says Chloride Industrial Batteries, is a semi-fuel cell offering an energy density 6–10 times that of a rechargeable lead-acid battery. Units smaller than an office filing cabinet can satisfy electrical load requirements from 200W to 2kW, giving back-up for telecommunications and other electrical applications for periods of up to 72 hours. They can offer a viable, more environmentally acceptable alternative to diesel generating sets.

In fact environmental concerns are boosting interest in the development of battery-powered cars and commercial vehicles, especially in congested cities plagued by growing pollution from the petrol-fuelled engine. According to Frost and Sullivan, current designs use lead-acid batteries and sometimes nickel-cadmium, but considerable interest is being shown in new battery technologies. By far the fastest growth is forecast for nickel-metal hydride designs, followed by valve regulated lead-acid batteries. Lower growth is forecast for vented lead-acid types, which are still preferred in many motive power applications, and this will result in an increased market share for valve regulated types. The lead-acid sector will, however, remain the largest and could be worth over \$906 million by 1996.

Credit Cards Getting Smart

Although BT is still denying that is about to launch its own combined credit and charge card, it is still, as is the case at Mercury, planning to introduce a multi-functional public payphone where users could opt to pay in cash, by a phone card or by a credit card. Unlike the US carrier AT & T who use a non-standard charge credit card, BT looks like settling for a credit card co-branded with the BT logo.

Meanwhile Talkland, a major cellular equipment supplier, sees credit cards becoming closely involved in data collection, capture and customer servicing. It looks like we will soon have to find wallet space for yet another card!

EuroSpeak

A report from the Commission of The European Communities points out that, with the exception of ex-East Germans and the Irish, young Britons aged between 15 and 24 are worse than the rest of their European counterparts at being able to hold a conversation in any foreign language. In fact a random sample found that only 50% of young Britons had any knowledge of a foreign language. Top of the EuroTalk league were young Luxembourgers, followed by the Danes, Dutch and Belgians. However, when it came to computer literacy, British youth equalled the Luxembourgers with 17% claiming a very good knowledge of computers. The UK also scored well on foreign travel, with only 22% of young people questioned saying they had never been abroad. The figure was 21% in France, which borders six other nations. Surprisingly, in ranking the importance of languages that young Europeans would like to learn, English has dropped from first to fourth place and Italian has jumped from fourth to second place. Top ranking choice of language in the survey was German.

That UK computer literacy figure could be helped by the news that BT has set aside £175,000 for a two-year project designed to give school children access to communications technology: project 'Gemini' is being run in conjunction with the National Council for Education Technology. Meanwhile a class of 13 year olds in Northern Ireland have been issued with Apple Macintosh Powerbooks as part of a research project. Other schools will be experimenting with Toshiba and Research machines in a project to discover whether small personal computers or notebooks have a place in curriculum work, reports 'Computergram'.

A somewhat more advanced project has been launched by IBM in a Chicago-area pilot programme to provide around-the-clock computer services to students in six schools. 500 students, together with 75 teachers, will be using IBM computers and software for use in the project 'Home-room', in order to help accelerate the uses of computers and telecommunications in homes.

More Little and Large

On view at a recent industry event by Microsoft was the world's largest, and least portable, computer. It measured 29 feet wide and 21 feet tall, with a mouse the size of a truck. Also, at the same show, Dell confirmed that it was working on a sub-notebook computer. Weighing in at under 4lbs, the product will be smaller than a 8½ by 11 inch notebook, use a flash-memory card for a floppy and have no hard drive in its base configuration. The price however, at \$1,500, is not so small.

Business Software Challenge

Cash, hardware and software prizes totalling £20,000 is on offer to higher education students and institutions submitting the best software design solutions to identified business problems. The Young Business Software Designer Competition, which is sponsored by a computer consultancy, aims to reward the wealth of talent which exists among young software designers at a time when computer software is playing an increasingly crucial role in shaping businesses worldwide. The contest closes 30 April 1992. Details: (071) 8 1 6262.

Keeping it Dark

One of the more unusual News Report venues recently was however, familiar terrain to Maplin Electronics' intrepid 'Out and About' compiler. The Securicor Telecoms launch of a new business telephone system took place amid the sound of air raid sirens, within the Cabinet War Rooms, deep under Whitehall.

The new hybrid PABX, the Rhapsody Rio, which is manufactured by Fujitsu, provides facilities above the 16-line, 48 extensions option currently being marketed by Securicor.

Ever since the company purchased Ferranti Business Communications, Securicor has been keen to broaden its telephone interests. Already the Group operates the largest private mobile radio system in the UK, servicing the needs of its cash-carrying and express parcel services and customers. The Group is also a 40% shareholder in Cellnet.

Child's Play

Now the team that gave us the Nintendo video entertainment system has become a major comms industry player. In association with such established names as Tandem, Control Data, and Mitsubishi, Nintendo is providing the interface which allows households access to real-time computer systems. Apparently, what was seen as an experiment to attract 5,000 households to buy and sell securities, mushroomed to some 200,000 home stock trading users. As Mike Sutin of the Adams World group of North London computer dealers comments, Nintendo games are currently all the rage. The TV-based home applications look like having equal success. But Mario, the little star of the game, has been criticised by a leading US professor: "The world of Nintendo is one of violence and mayhem", he says.

Travelling Abroad?

Confused about the many regulations, security and damage from X-ray machines to your information sources when you travel abroad with your PC? Well, Compaq Computer has used its experience gained as a leader in personal computing to assemble a new pocket-sized reference guide for UK-resident users, called 'Travelling Abroad With Your Portable PC'. Subject headings covered in the free publication include: Documentation; Airlines; X-Ray Checks; Service and Insurance; and Useful Addresses. Single copies of the black leatherette booklet can be obtained, free of charge, on application to Compaq Marketing, c/o FREEPOST, Dept. 4335, Bristol BS1 3YX, or by telephone on (0345) 300199.

More book news. The Cognito Pocket Guide to Mobile Communications provides an informative explanation

on the latest developments in the industry, with the aim of de-mystifying some of the technical jargon that is so often used. The 100-page guide to mobile communications is available at a cost of £5.95 from Cognito Group Ltd., Medway House, Newbury Business Park, London Road, Newbury, Berks RG13 2PZ.

Commonly known to all involved in the computing world as the 'Industry Bible', The Computer Users Year Book 1992 is now available at £130 - £6.50 (UK). Despite the recession and the volatile market, there has been an increase of 12.5% to the entries in the four volume large reference guide. The microcomputer section now lists 750 different machines, an increase of 28% since the last edition. Just about the only decrease shows up in recruitment services. It certainly comes into the 'right riveting read' category.

GSM Rolls Out

On view at the major telecoms shows at Geneva and Brighton late last year was the UK's first digital, Pan-European, mobile telephone service from Vodafone. The new service conforms to the standard agreed by 16 European nations, and means that we will ultimately be able to make and receive calls while travelling across Europe. For the first stage the Vodafone GSM service will be introduced into the central London area, and by Spring this year should cover much of the South East. However, as Chris Gent, managing director of Vodafone, says, GSM does not come cheaply. The capital cost for the installation of a nation-wide GSM network will probably be close to £120 million.

Hole in One Plus

One of the best selling introductory CDI promotional packages released by Philips is 'The Golfers Package'. However, Cray Research are also introducing high technology into golf. Cray is using a super-computer to help a producer design a better golf club for straighter shooting. The computer simulates what happens when a golf club strikes a ball at 100 mph, the approximate speed of a typical swing.

Car Comms

According to the BBC, up to two thirds of new cars sold in the UK this year will come with Radio Data System (RDS) radios fitted as standard. Rather than displaying the frequency, the equipment will display the name of the station and automatically re-tunes as the car enters an area where the station uses a different frequency. The sets will also have the ability to interrupt a broadcast or tape to switch to a traffic announcement.

Such a system should be of interest to local authorities around the world, exploring high-tech ways of solving the traffic congestion problem. Planning authorities have largely given up on the traditional answer to congestion, namely building more roads, says research organisation Frost and Sullivan. High tech solutions include route guidance systems and a method of feeding traffic helicopter broadcasts into large automated systems to collect and re-distribute traffic information on a special radio frequency.

Meanwhile, John Redwood, Minister for Corporate Affairs, told a conference that the mobile phone is becoming commonplace, and called on foreign regulators to follow the UK lead in promoting competition and open markets. Hopefully they will not follow the UK governments lead and slap a tax on the usage of mobile phones.

Have a Nice Day

Vodata Services, part of the Vodafone Group, has signed up with the UK Met. Office to provide dial-up fax weather forecasts. This concept, new to the UK, allows anyone with a Group 3 fax machine or PC fax card to dial a pre-arranged number and, instead of sending a fax, the unit will receive a printed forecast. The system will also be able to supply financial summaries, road maps and travel information, entertainment fact sheets, holiday information and sports reports.

Radio Waves

It should be no surprise to learn that the radio spectrum is under pressure. In particular there is a congestion of frequencies below 1GHz, the range best suited to mobile radio applications. International meetings are being held by The World Administrative Radio Conference of the International Telecommunications Union to try to sort out frequency allocations. Current European proposals include: 1520MHz-1525MHz, extension to existing land and maritime mobile satellite provisions. 1900MHz-2025MHz, made available in the year 2000 for new public mobile systems.

2100MHz-2200MHz, made available in the year 2010 for new public mobile systems. 2520MHz-2690MHz, made available in the year 2000 to provide two new 50MHz bands for mobile satellite applications. 2570MHz-2620MHz, made available for satellite sound broadcasting. 21.4GHz-22GHz, allocated to wide band high definition television broadcasting from satellites.

Babbage Works

The fortunate winners of the 'Electronics' Science Museum contest will be able to see for themselves the recreated Babbage calculating engine, actually calculating! For a variety of reasons Babbage himself failed to realise a complete design in physical form and, until this year, no one had seen a complete Babbage calculating machine 'in the metal'. Until now, Babbage's reputation as a practical designer has been in the balance. Final adjustments have now been made at the museum and the engine has successfully performed a long series of calculations without error. Well done Charles! He knew what he was onto, but was obviously too far ahead of his time.



PICTURE CAPTION CHALLENGE

Up in the clouds again this month. No prizes, but what exactly is going on?

- ★ Engineer fixing a new maximum security floodlight for a new prison.
- ★ Engineer fixing the world's biggest (and highest) mouse-trap.

★ Engineer fixing the last nut and bolt in the new wide area council tax evaluation scanner.

In fact it is a BT engineer working on a microwave dish on the top of Birmingham Tower.

Events Listings

14/15 February. The Universe Comes to London, The European AstroFest, Sponsored by 'Astronomy Now', Kensington Town Hall, London. (071) 580 210423.

February. Northern Cross Radio Rally, Rodillian School, on the A61. (GOFIX) (0532) 827883.

25/28 February. The IBM User Show, Birmingham. (071) 404 4844.

4/5 March. The Networked Economy. A major conference which 'brings together the individuals with the power to shape the telecommunications future.' Paris. (081) 868 4466.

11/18 March. CeBIT '92, major Euro-

pean technology event. Some 5,000 exhibitors will be on show in some 21 different halls. Hanover. (081) 688 9541.

31 March/2 April. CD-ROM Europe '92, Brighton. (0895) 622233.

7/10 April. The Which Computer? Show + Communications '92. NEC, Birmingham. (081) 940 3777.

13/15 April. Cable and Satellite, Olympia, London. (081) 940 3777.

24/26 April. The Third MIDI Music Show, Hammersmith, London. (081) 549 3444.

Please send details of events for the Diary Listings to The Diary Editor, 'ELECTRONICS'.

COMPUTER AIDED DESIGN & THE PERSONAL COMPUTER

by Frank Booty

The personal computer (PC) is now firmly established at the heart of Computer Aided Design (CAD) systems in companies throughout Europe. CAD as used on PCs now spans the range of CAD applications – from general purpose 2D draughting and design, to more demanding and processor intensive activities, like 3D solid modelling and finite element analysis.

In the CAD world, PCs are increasingly being used in preference to other hardware platforms such as mainframes, minicomputers and engineering workstations. Customers are discovering the benefits of the PC, which now includes:

Power: by harnessing the power of the 386 architectural family of processors, including the latest 486 processor, and optimising system throughput.

Open Architecture: letting the user choose from a rich variety of software and peripherals compatible with the industry standard PC and so configure a system according to requirement and/or budget.

Flexibility: allowing ease of connection between machines and the sharing of

computer data and resources over Local Area Networks (LANs).

Cost Effectiveness: delivering the best price/performance ratio across a range of products from 386SX to 486.

At the beginning of the '80s, only the largest aerospace and automotive companies were able to afford the £250,000 plus required for a super-mini based CAD system. But even when the designer was able to gain access to the system, response times on simple 2D tasks were very slow.

Although minicomputers have been the mainstay of the CAD environment, they are now seen as being increasingly expensive to install, maintain and upgrade, while offering a poor price/performance ratio. After these came the engineering workstations, which offered a turnkey solution and dedicated processing power. The workstation was, however, still relatively expensive and inflexible. Today, the PC delivers comparable processing power at low cost, with the added attributes of flexibility and compatibility.

Establishing a powerful and complex CAD system is no longer a cash draining exercise. One result is that many software houses have migrated their software to the PC, while others choose the PC as the platform of their choice for their

development work. Others, like Autodesk, have grown up with the PC and are moving ahead by taking advantage of operating systems like UNIX.

A factor in the inexorable rise of PC-CAD is the increasing level of processing performance offered by the PC, particularly the 32-bit memory and processing path of the Intel 80386 and 80486 microprocessors.

When the 486 DX microprocessor was introduced in 1989, it delivered twice the performance of the 386 DX for the same clock rate. With specialised RISC (Reduced Instruction Set Computing) operation yet offering an architecture 100% binary compatible with the 386 micro family, the 486 DX microprocessor combined the best of two worlds.

Scientific and CAD applications are manipulating ever more complex images in true 3D with colour and animation, and using built-in design intelligence to apply design rules and analysis – all of which demands more power. Then there is the updating of big graphics files, more lines of code, multi-tasking, networking, data communications and more complex output requirements. Adding the 487 SA

Range of SUN workstations.



math co-processor increases the speed of math intensive software applications by up to five times over the 486 SX. By integrating the floating point unit and CPU functions on chip, the 487 SX math co-processor delivers up to 70% more performance than a 386 DX CPU plus 387 DX math co-processor based system. Aside from the CAD applications, such systems are suited for spreadsheet work and business graphics (i.e., mathematical operations involving very large numbers, floating point numbers, complex calculations and graphics).

Even CAD applications that were assumed to require special hardware, e.g. solid modelling and finite element analysis, can be managed on the PC. Meanwhile, many of the technological innovations introduced on mainframes, such as cache memory, disk buffering and floating point accelerators, have been incorporated into PCs.

Personal computers were once traditionally viewed as a stand-alone resource. Now, many users of CAD utilise networks to share information between departments and between companies. Since, during the life of a design project, many people need access to the same data, the sharing of drawings, financial and planning data can improve productivity and product-time-to-market. Market researcher IDC estimates that the number of personal computers utilised in networks will increase from 34% of all PCs in 1989 to 55% in 1992. Once again, this trend has allowed leading PC manufacturers to incorporate features into the standard PC, optimising them for networked environments.

It is worth noting that no designer spends all day on creative work, since most people are saddled with administrative or management duties. The administrative function might also involve the use of software, chosen from the hundreds of word processing, desk-top publishing, database, spreadsheet and project management packages written for the PC. The PC-CAD user can not only run a mix of CAD applications, but also cost-effective business productivity software on the same computer.

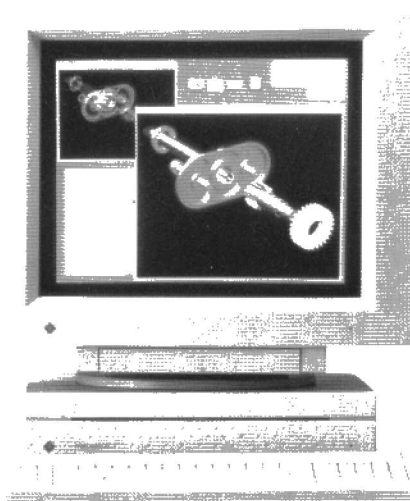
When the user decides to upgrade, the PC does not lose its value. As the new PC arrives, so the existing one can assume a different role within the company (e.g. passed to a junior designer or moved to a different department such as accounting).

CAD has come a long way from its beginnings in the early 1960s. The real benefits of using CAD in the design cycle include:

INCREASED PRODUCTIVITY

Businesses involved in projects that require a great deal of repetitive work, modification or updating are the real beneficiaries of CAD. Parametric programming can generate families of parts at the touch of a key. Macros enable users to customise frequently used calculations or to tailor sequences to their own ways of working.

Typically, drawings can be created at



a scale of 1:1 and output at all the different scale factors required by contractors and allied trades in a multi-disciplinary project. Even with one-off products, the computer's skills at handling complex geometric constructions and using libraries of standard symbols can improve efficiency.

In addition to the productivity benefits inherent in moving from manual to computer based design methods, installing PC based Local Area Networks (LANs) allows even greater productivity gains. The key here is the exchange of design and drawing information, within and between departments.

SHORTER LEAD TIMES

CAD speeds up the design to production cycle, getting better quality products out to market faster and giving companies that use CAD a competitive edge in world markets. Firms can take the opportunity to open up new markets and produce more diversified and targeted products.

Top: 3D solid modelling on a SUN.
Below: Compaq Deskpro 486/33L, described as the world's most powerful PC for CAD applications.

IMPROVED ACCURACY

Via cleaner, legible and more precise drawings, CAD can eliminate ambiguity (and 'draughtsman's licence') from designs and give designers the confidence that their concepts will not be compromised as they travel downstream through the design to production process. CAD means more communication between management, engineers, designers, sales and clerical staff.

BETTER QUALITY DESIGNS

Despite a common apprehension amongst non-users, CAD does *not* stifle creativity. CAD gives the designer time to try alternative 'what if?' solutions. Analysis, simulation and evaluation programs mean that 'no hoppers' are caught on the screen, rather than the shop floor. The need for prototypes might not be eliminated, but fewer of them should be required, while the ones that do have to be made will be closer to the final product.

As legislation on product liability becomes increasingly important to the manufacturing industry, new methods must be found to help designers avoid errors, predict potential pitfalls and prevent them occurring, as well as to control the escalating amount of complex data associated with product reliability and safety.

MORE ACCURATE COST CONTROL

With CAD it is easier to work out exactly how much a product will cost to make, so that stock and work in progress can be reduced in line with current just in time (JIT) practice. Materials and machine time can also be saved by using optimisation and 'nesting' routines. Engineering drawings also take up a great deal of space – storing the information in a computer database not only makes it more accessible and more likely to be consulted, but also liberates valuable office space.





MORE AND BETTER MANAGEMENT INFORMATION

Since documentation will be up to date, managers will have a better appreciation of what is going on and where potential pitfalls might occur. If the geometry of the product – plus its associated alphanumeric attributes – is held in the computer as a database, then everything that is needed to be known about making the product (drawings, parts lists, manuals, tapes to drive machine tools) is automatically accessible.

These are the most striking benefits of CAD, but PC-CAD adds another factor – all these benefits are now affordable by one or two person companies or by individuals within departments of large organisations. A CAD system built around a PC will look, feel and perform like the super-mini based system of a few years ago.

The crucial difference is that a PC-CAD system suffers no degradation of response as more users log into the system for the reason that the processor on the desk can now be assigned to the designer or engineer's exclusive use. So PC-CAD is finding a ready market.

According to recent figures from the market research company Dataquest, Compaq is leading the UK PC-CAD sector with a 55% share.

Traditionally, CAD was used in medium to large multi-national companies, notably those in the automotive and aerospace industries, to help design mechanical and electro-mechanical parts. More recently, there has also been a large take-up in the construction industry among architects, structural engineers and allied building trades – to the point where specifically targeted AEC (architecture, engineering and construction) versions of popular packages have been developed to cater for the particular needs of this group of users.

Electronics too has taken to CAD with enthusiasm and many multilayer PCBs (printed circuit boards) and VLSI (Very Large Scale) integrated circuits would have been impossible to design and manufacture if it wasn't for CAD. Today, there are as many PC-CAD applications as there are users. Digital mapping, to name but one, is becoming an increasingly popular application as local government authorities, in particular, discover the benefits of storing maps and map data on PCs – where it can be accessed by many users and updated efficiently.

PC-CAD has opened up the list of applications to virtually anyone who requires a drawing in the course of their work. Every small company or individual within a department of a large corporation can now afford the advantages and benefits of CAD. With the advances in connectivity and standards, users can be confident that they will be able to receive and pass on data in digital form – increasing efficiency and reducing error. Compaq, which has targeted the CAD market-place, is also committed to developing the PC architecture to take advantage of the new generation of high-speed peripheral devices, such as disk drives and networking boards, expected in the future. Compaq was one of the founders of the Extended ISA (Industry Standard Architecture) consortium – committed to developing full 32-bit computing support for the PC that will remain compatible with existing 8 and 16-bit devices.

Today, Compaq's Deskpro 486/33L EISA system delivers high performance real time graphics capabilities. Now, the company has announced the Deskpro 486/50L which uses the latest 50MHz 486 microprocessor from Intel and is said to provide 50% greater performance over the fastest 33MHz 486 based PCs.

The company claims to combine engineering quality, reliability and innovation with adherence to open, user-

Compaq Deskpro 486/50L runs at 50MHz.

driven standards. Compaq has pioneered the development of the high performance PC and introduced many of the key innovations that have enabled the PC to drive demanding CAD applications.

PC architecture delivers a price/performance level unmatched by any other hardware platform. The benefits of CAD can now be made available throughout a company, with users able to share data and resources or easily integrate with other computer systems.

GLOSSARY OF CAD TERMINOLOGY AND ACRONYMS

AEC: Architecture, Engineering, Construction – the US term encompassing building design and civil engineering applications.

Bitmap: A one-to-one array in memory of the pixels on the high resolution screen – a bitmap circle, unlike a display list one, does not 'know' it is a circle.

BOM: Bill Of Materials – using the discipline of a CAD system, i.e. naming parts and giving them physical attributes as they are created on the screen, can result in automatic parts lists. Add purchasing information, supplier details and current prices and you have an accurate bill of materials automatically generated from the central database.

Display List: A list of co-ordinates and formulae in the computer's memory that defines a component's geometry, as opposed to a bitmap that merely stores the pixels as they appear on the screen.

CAD: Computer Aided Design, or more exactly in the case of 2D systems, computer aided draughting.

CAM: Computer Aided Manufacturing – all the downstream shop-floor activities such as NC and production planning that can make use of the part's geometry as it is output from the CAD system.

CADCAM: Joining the two acronyms does not necessarily ensure integration of design with production, though nowadays the two types of system can be run on the same machine.

CIM: Computer Integrated Manufacturing – the ultimate aspiration of the CADCAM vendors, to link up design systems with the means of manufacture, i.e., machine tools, robots, automatic guided vehicles and materials handling systems, e.g. via MAP/TOP communications.

.DXF: Autodesk's de facto file format, now used by most other vendors for translating drawings between different makes of software. Output from Autocad can serve as input to another application.

FEA: Finite Element Analysis – breaking down a component's geometry into a mesh of simple shapes that can be analysed for stress and thermal properties. FEA programs are very large and are often sent off to a batch number cruncher for processing; PCs usually run the pre and

post processors that build the mesh and display the results in the form of coloured contour images.

Hardcopy: CAD users demand the highest quality output, so usually opt for a pen plotter A1 size and above. Being electro-mechanical devices, these can often cost more than the rest of the system put together. Electrostatic plotters are faster (they plot in rasters like the screen, so are not slowed down by the complexity of the image) but are also more expensive especially for colour plots. Dot matrix, thermal transfer and laser plotters can be used for quick check plots at small scales.

IGES: Initial Graphics Exchange Specification – an evolving international standard for exchanging CAD files between different makes of system via a neutral format. Most users prefer direct translators as less information is lost.

ISO/OSI: The seven layer Open Systems Interconnection model for networking devised by the International Standards Organisation; takes in Ethernet and MAP/TOP.

LAN: Local Area Network – a network of PCs, workstations or super-minis sharing files and peripherals (disks, plotters, etc.) within the same site, locality or campus – Ethernet, developed originally by Xerox, is perhaps the best known LAN.

MAP/TOP: Manufacturing Automation Protocol, and its Technical Office Protocol

equivalent, devised by General Motors so that systems from different vendors can be connected together in a network for the transfer of common data.

MIPS: Million Instructions Per Second – the common way of quantifying the speed of a system. Speed is also dependent on the efficacy of the application software and the skill of the user.

NC: Numerical Control, as applied to machine tools, can be DNC (Direct Numerical Control) where the machine is hardwired to the CAD system, or CNC (Computer Numerical Control) where the part data is passed physically from the CAM system to the machine via paper tape.

NC part programming: Converting the geometry of a component output from a CAD system into an efficient tool-path for the appropriate machine tool to manufacture the part, and verifying that there are no clashes between the tool and the part's fixtures.

NFS: Sun's de facto standard for sharing geometry files around an Ethernet LAN, now adopted by most other vendors. Stands for Network File System.

Parametric Programming: What CAD is really all about – an almost automatic method of generating drawings of components having a family resemblance by first defining a generalised component shape and subsequently inputting specific dimensions.

Pixel: An addressable portion of the screen, short for picture element. A screen's resolution is defined as the number of pixels horizontally by the number of lines vertically.

Production Planning: Non-graphical programs associated with the design to manufacture cycle, such as MRP (Manufacturing Resource Planning), scheduling, bills of materials.

Solid Modeller: A CAD system, e.g. Robo Solid, that produces a complete and unambiguous model of the component that can be 'weighed' and checked for interferences with other objects.

Spline: The computer equivalent to the French curve, but more controllable, e.g. NURBS, for Non-Uniform Rational B Spline.

Surface Modeller: A specialised 3D CAD module used for designing objects with complex doubly-curved surfaces, such as those defining turbine blades, automobile bodies and telephone handsets – not usually integrated with wireframe or solid modelling systems.

Wireframe: A 'transparent' 3D representation of an object made up of lines and points, but no surfaces.

2½D: A simplified version of 3D in which an x, y 2D profile is 'extruded' in the z direction (denoting 'depth') to generate a shape with no undercuts.

CALLING ALL ELECTRONIC ENTHUSIASTS!

Are you a dedicated electronics enthusiast? Do you build projects and kits? Have you designed any innovative circuits? If yes, and you would like to appear in the pages of 'Electronics – The Maplin Magazine', then now is your chance! Send brief details of yourself and a list of projects that you have built, to the Editor, together with any other information that you feel is relevant. You could then find one of our reporters calling on you to discuss your favourite hobby!

Write now to:
The Editor, 'Electronics', P.O. Box 3,
Rayleigh, Essex, SS6 8LR.



Velleman K4000 Stereo Valve Amplifier

Part One – The Review by Alan Williamson

For those of you who have lusted after a valve amplifier for years, but are unable to afford one due to their high cost (compared to transistor designs), your fetish can now be satisfied. With the introduction of the Velleman K4000 valve amplifier (tube amplifier to our American friends) into the Maplin range of kits you can now turn your fantasy into reality. The K4000 is a fixed-bias ultra-linear design, delivering 95 watts in class A/B1 (see below), the first 15 watts are in class A.

Classy Operator

Class A is the situation when the anodes of both valves on each half of the output transformer primary are conducting at all times. Class A/B1 operation occurs when a signal is large enough to cut the valve off during the negative half of the cycle (only one valve is cut off at any time because of the inverted phase) and the cathodes are always negative with respect to the grid.

Specification

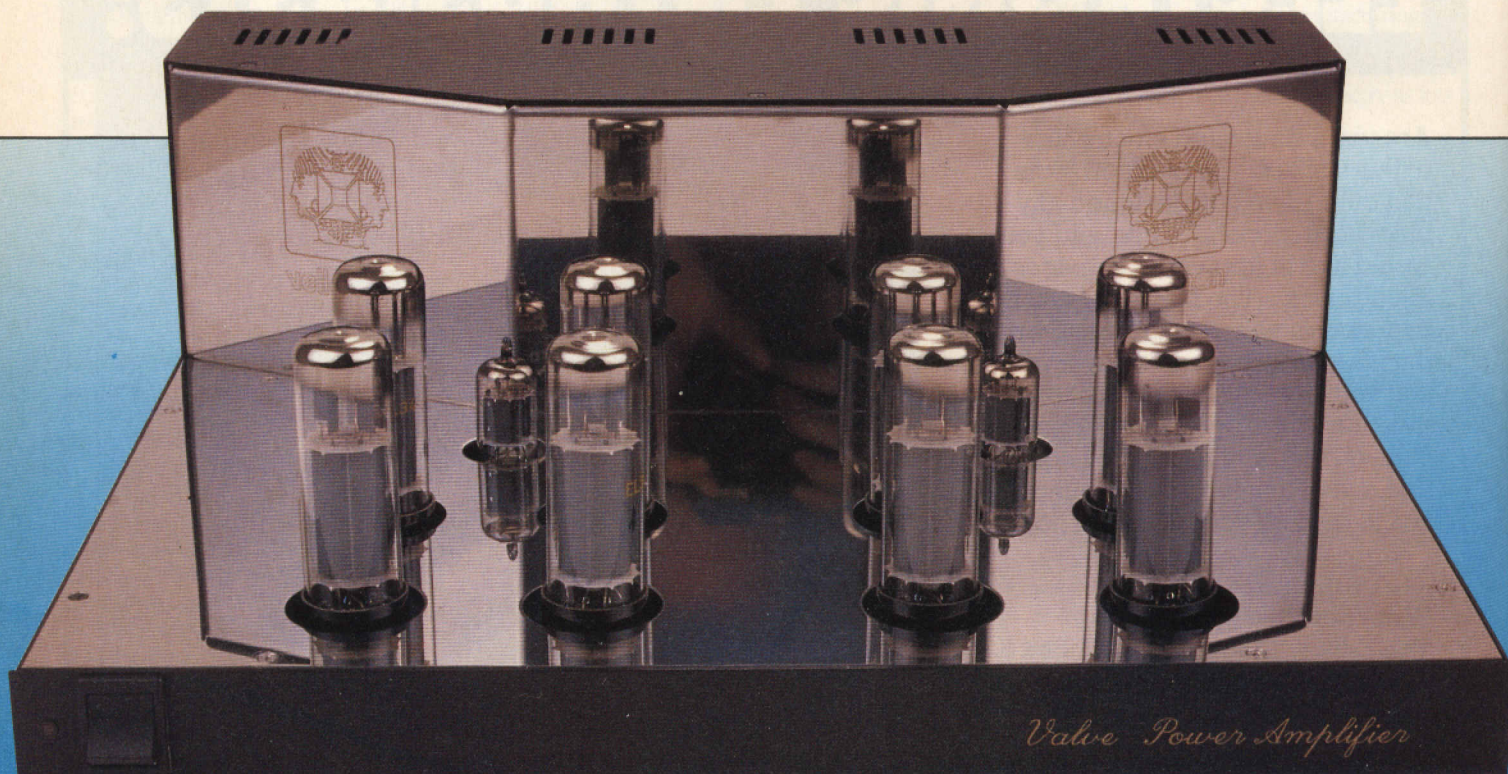
| | |
|--------------------------------------|---|
| Output power: | 2 × 200W music power 2 × 95W rms in class A/B1 2 × 15W in class A |
| Power bandwidth (max. output, -3dB): | 10Hz to 60kHz |
| Frequency bandwidth (ref. 1W, -3dB): | 4Hz to 100kHz |
| Harmonic distortion: | 0.08% (1kHz, 1W) 0.63% (1kHz, 95W) |
| Signal to noise ratio: | >102dB (A weighted at 95W) |
| Channel separation: | >67dB (at 95W) |
| Input impedance: | 100kΩ |
| Input sensitivity: | 0dB (775mV for 95W) |
| Loop feedback: | 18dB |
| Damping factor: | 25 |

Incidentally, Class A/B2 operation is such that, when one valve is conducting and the cathode of the other valve is driven positive with respect to the grid; this requires power to drive the grid rather than a voltage.

Weight Training

So what do you get for your money? Well for a start you don't get a flyweight

amplifier (it weighs 20kg!), the physical dimensions are 423 × 383 × 150mm (whd), including the mains switch and speaker terminals. In the kit you get everything you need to build the amplifier, right down to the last nut and bolt. You may, however, prefer to use an alternative audiophile cable and components (see later) to those supplied with the kit – please let us know the results.



The impressive looking, and sounding, K4000 amplifier.

When built, the amplifier is rather eye-catching – with the valves on display, as can be seen from the photograph. Styling is in a similar fashion to that of the Beard P35 or Audio By Design (formerly Audio Innovation) First and Second amplifiers.

Circuitry

The amplifier is a little unusual as it employs toroidal transformers in the output stages and power supply, but the rest of the circuit is fairly standard.

Referring to Figure 1, the input of the amplifier is AC coupled to one half of an ECC82 in the preamplifier stage (the other half being used for the other channel). The ECC82 is used as a buffer and pre-gain stage, without the use of cathode decoupling, and is not included in the feedback loop.

An ECC83 is used in the main amplifier proper. Half of the ECC83 is used as a gain stage, with the overall feedback loop terminating at the cathode, while the other half of the ECC83 is used as a phase-splitter.

The outputs of the phase-splitter then feed two parallel pairs of EL34s in the fixed-bias ultra-linear push-pull configuration. Power from the output valves is converted from high voltage low current, to low voltage high current via the ultra linear transformer, connections to the outside world being made by either the 8Ω or 4Ω tap, the overall feedback loop is taken from the 8Ω tap.

Although the EL34s are running at near maximum voltage, each valve is only delivering around 24 watts. A single EL34 can handle a maximum 48 watts, so you could say that the EL34s are conservatively run, which helps to extend valve life.

The Meaning of Life

A nominal figure for the lifetime of a valve is given at around 5000 hours, but valves should be replaced on a fairly regular basis, around every 1000 hours or so.

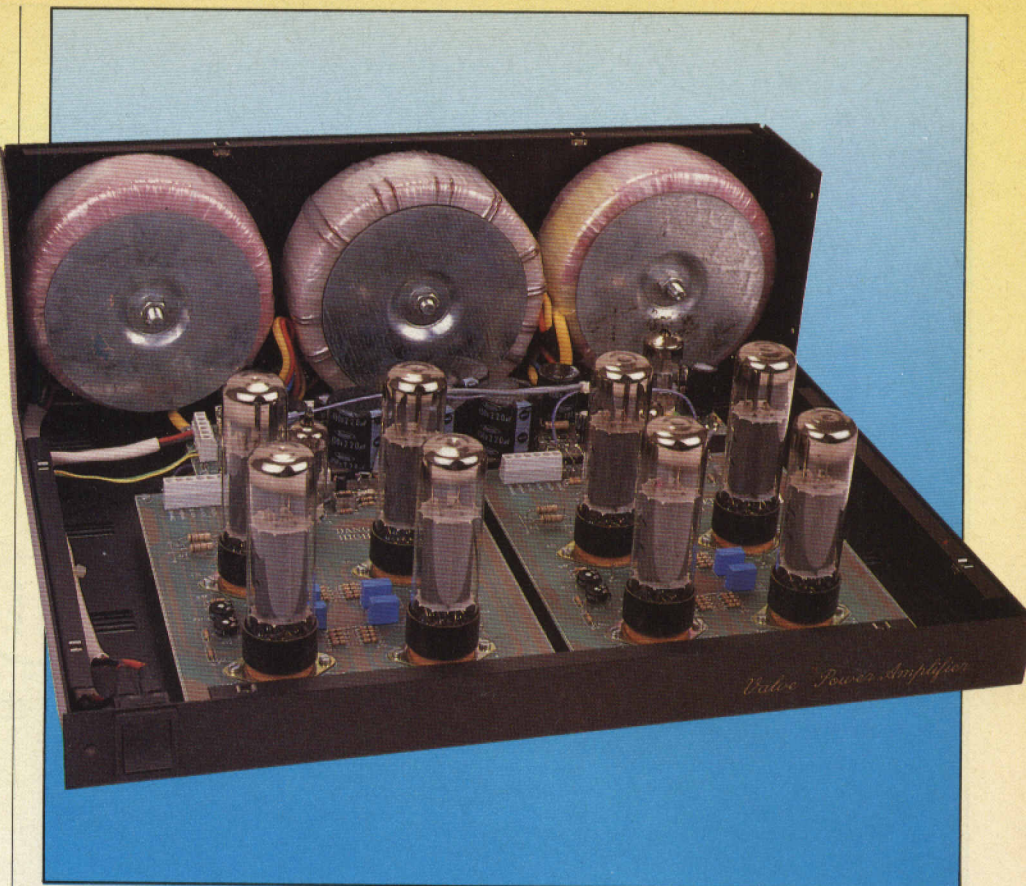
Ageing valves are generally noticed by a softening of the sound which can manifest itself in different ways, a loss of detail in the treble; speed, slam and articulation in the bass; a general blurring of information and a fuzzy stereo image.

Terminal Condition

WARNING: The amplifier must always be terminated with a speaker load BEFORE powering up, otherwise serious damage to the output valves and/or transformer may result.

Large Scale Integration

The amplifier was slotted into my usual stereo, which took the place of my trusty Edison Twelve (also valve, a triode coupled class A, 12 watter), although the Edison is no longer in production, the nearest living relative is the Audio by Design series 200, which sells for approximately £450 (at the time of going to press).



The K4000 with its covers removed.

The rest of the system consists of a Voyd Valdi turntable fitted with a Rega RB300 arm and Audio Technica OC7 cartridge, this feeds a home made head amp (based around the LT1028 Op-amp, better than my Audio South transformer, but that's another project). The preamp (valve) is a heavily modified Audion Premier. The speakers are a temporary pair of LNB 7s (a 70 litre transmission line design). Audio Note silver interconnects and Audio Note green/white speaker cable were used to stitch the system together.

A little consideration must be used when siting the amplifier. If you have children or pets you won't be able to leave the amplifier on the floor, and I doubt a shelf would be strong enough to take the weight. Placing the amplifier between the speakers or on large cabinets is also a no-no, otherwise you may end up with a feedback problem. You won't get a howl-round, but it will affect the sound quality (valves are mechanical devices, if you tap or flick any of the valves with your finger nail, you will be able to hear a ping from the speaker(s) which will last for several seconds – a characteristic commonly known as 'microphony').

Another thing that must be taken into account is that the amplifier needs plenty of ventilation, so you can't put it into a cabinet. The amplifier should also be kept out of draughts and away from plants – plants don't always like the hot air! The other reason you should keep plants away from the amplifier, is that some of them sweat and, sometimes, 'those people with green fingers' are not always careful when watering. Water dripping onto a hot valve, even a single drop, would prove disastrous ending up in a pyrotechnic display – pretty but expensive! At the

end of the day it would be best to use the amplifier on a proper equipment table, such as the ones manufactured by Target, Mana Acoustics, Oasis, Sound Organisation, etc.

Acclimatisation

Serious listening didn't take place for a couple of days – until the amplifier had settled in. I used the time to re-adjust to the sound my stereo made using this amp, which is quite different from what I am used to.

The first thing I noticed about the amplifier was what 'appeared' to be a lack of top-end, I say 'appeared' because the top-end is all there, it just doesn't grab you by the throat. I also discovered during the first couple of days that the Audion is not an ideal match for the Velleman, which didn't help matters.

Substituting the Audion for an 'experimental' bodged-together transistor preamp brought the top-end out alright, only now it was slicing my ears off!, so the Audion was recommissioned for the listening tests and the 'experiment' went into the bin.

Eventually I was able to jiggle the tonal qualities of the system to something that was acceptable by changing the interconnect and speaker cable.

Serious Listening

The sound stage is more tangible and three dimensional than the Edison, the stereo image has good depth and height, the width extended well beyond the speakers, but I did notice a couple of things. The musicians seemed to have taken a step backwards into the mix, this was not a bad thing really as the sound stage became more stable and realistic.

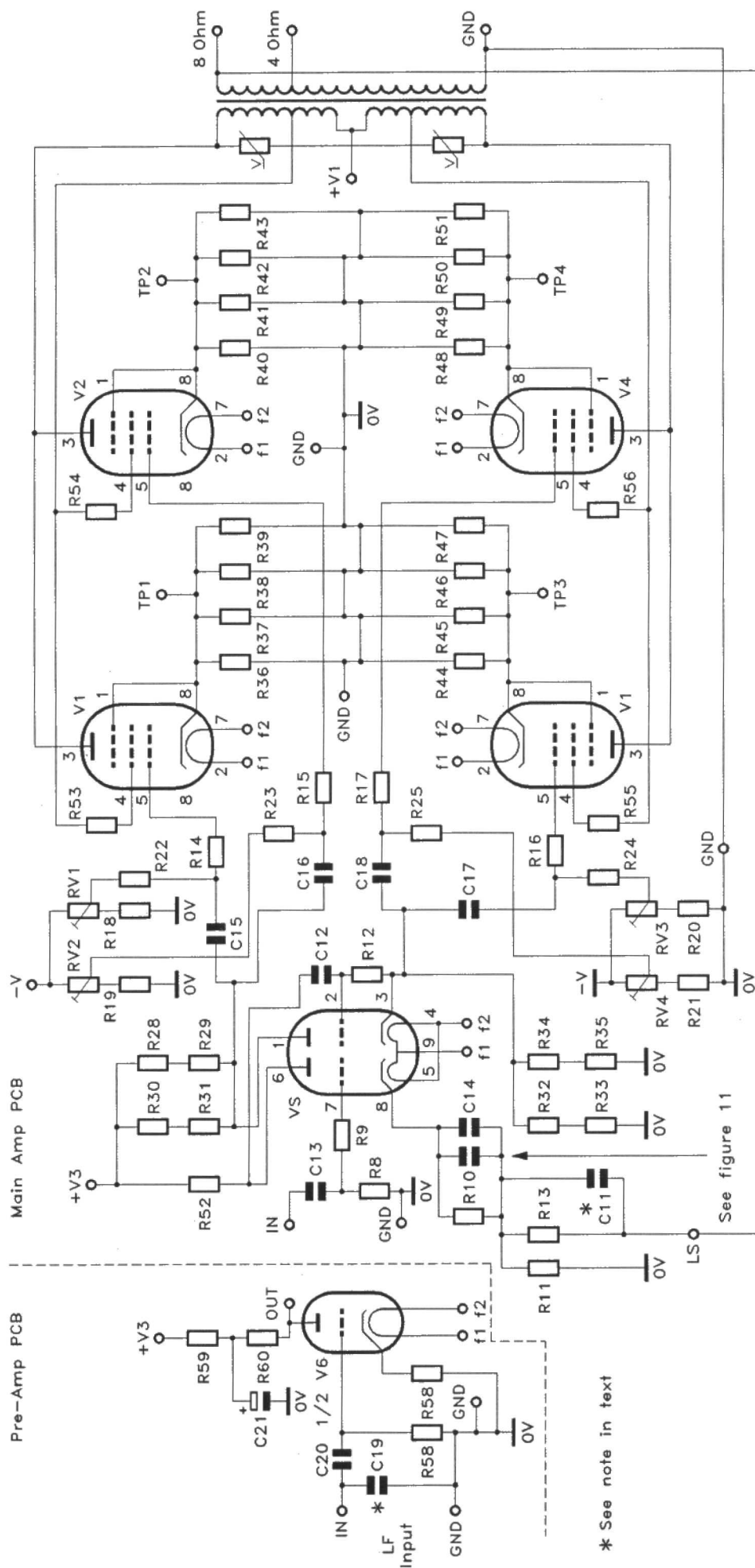


Figure 1. The circuit diagram of the K4000.

The other thing I noticed was that the stereo image seemed to be grainy, similar to looking through a net curtain or looking at a photograph printed in a newspaper. I wondered if this graininess could be due to the ceramic capacitors in the circuit? There are two per channel, one at the input of the amplifier and the other is in the feedback loop. I replaced both of them with polystyrene types (4 in total, BX24B and BR37S). The sound quality improved quite a bit and the stereo image wasn't grainy any more. It seemed as though someone had filled in the area between the spots! The mid range and treble was also of a more liquid quality, a simple and worthwhile modification.

The one thing that really impressed me about the amplifier is the amount of grunt it has in the bass; it is deep, solid and powerful, basically it's got balls, even at low volume.

After listening to the Velleman for a couple of days, I felt that I was not really going to be able to find the limitations of this amplifier in my system. A quick phone call to my friend arranged the use of his stereo over the weekend.

My friend's system is what some might call 'over the top' depending on your point of view. The turntable is an Omega Point Mentor, fitted with a Breuer type 8 arm and a Kiseki Blackheart cartridge, Audio Research SP11 preamp, two pairs of Ray Lumley M150 power amps and Snell AIII speakers. The system is wired together using Cardas interconnect and speaker cable.

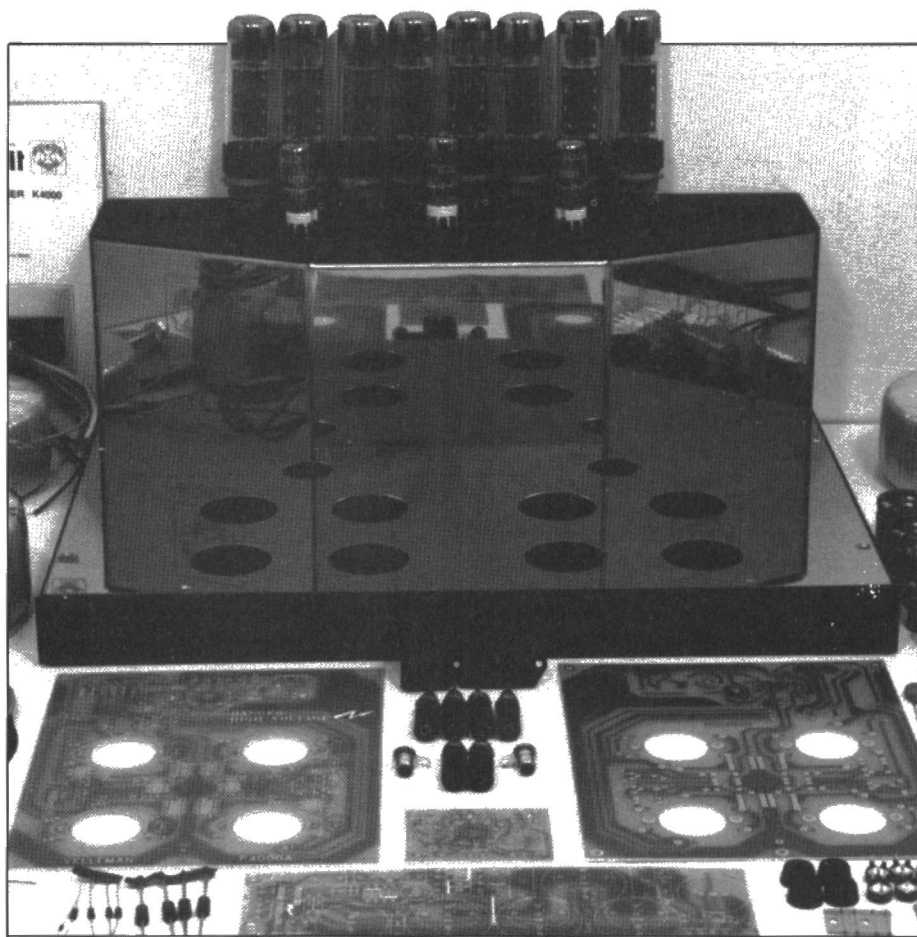
Both pairs of Lumleys were disconnected and the Velleman was slotted in place. Unfortunately because the Cardas cable is so large, the Velleman would not accept two pairs of cables so the Snells could not be bi-wired. Half an hour was allowed for the amplifier to warm up before listening commenced.

A record was put on the turntable, the arm cue lowered and we both sat back to listen. After the first track my friend looked at me and said, "Hmmm, ... ain't bad is it!"

My initial comments about the lack of top end is unfounded in this system. Although the top end didn't sparkle quite as much as with the Lumleys, it certainly wasn't dull, but it was improving all the time, even after 4 hours of continuous music it was still getting better.

I have a feeling that with the amplifier's excellent dynamics and tonal characteristics, it has primarily been designed with CD in mind, unfortunately I didn't have one to hand to confirm my suspicion.

I have to admit the performance of the amplifier did surprise me a couple of times. Playing 'The Game' from Nusrat Fateh Ali Khan's *Muhammad Mustaf* album (Real World LP15) made the floor shake in a very meaningful way. The Velleman was making the Snells move a lot of air, so much so that my friend is now considering replacing a pair of the Lumleys with the Velleman to drive the bottom half of the Snells. (A pair of Lumleys are more than



The K4000 kit of parts.

7½ times the price of the Velleman.)

The other thing that surprised me was that the Velleman didn't sound too out of place in a system of this calibre, it has its limitations; even the Lumleys have limitations, but there again doesn't every thing!

This amplifier loves music, any music, especially solo acoustic. The double-bass and tablas on the track 'Prancing' from Colin Walcott's *Cloud Dance* album (ECM 1 1062) was very holographic; I could almost walk around the instruments. The sitar and double-bass on 'Eastern Song' from the same album had wonderful presence, the whole room seemed to energise. Small nuances could be heard on the Egberto Gismonti *Sol Do Meio Dia* album (ECM 1 1116). I could hear the rasp of his fingers moving over the strings, I also could hear his sleeve brushing on the guitar body quite clearly, the saxophone also had a lovely bite to it, spine tingling even.

Modern pop/rock/indy recordings (although not the best) are reasonably well reproduced, I thoroughly enjoyed listening to 'Fishing and Bags' on PILs 'Album' (Virgin OVED 245). Morrissey's *Alsatian Cousin* (Viva Hate, HMV label, Virgin CDS 3787) just totally bowled me over. Another surprise the amplifier had in store for me was that I originally wrote-off Big Audio Dynamite's *Megatop Phoenix* album (CBS 465790 1) as a poor recording. Not so, the bass and drum kit via the Edison was over blown which was most evident on 'Start, Rewind and The Green Lady', it was previously about as tight as... [I'm sorry but I can't print that - Ed!]. But when played through the Velleman it is tight and very deep, it's just that the Edison bottles out - sic.

On the down side, the only faults that stick out are that the amplifier does tend to lose the fine detail of the music and it does tend to compress the three dimensional image into a wall of sound when the going gets fast and furious (the amplifier didn't like the Sex Pistols [who does? - Ed.]). But there again the Velleman doesn't carry a state-of-the-art price tag and you also have the fun of building it yourself.

During the listening tests I was limited to the amount of equipment available, I would have liked to have had a chance of using the amplifier with a wider variety of speakers. But given the amplifier's tonal characteristics it should be able to fit in to any good quality system that is on the neutral to bright side, or any one using a pair of small speakers that could do with a bit of beefing up.

Unfortunately, I am not able to vouch for the amplifier's performance with difficult (highly reactive) loads, a pair of full range ribbon speakers would have been handy to find out how the amplifier coped.

To fully exploit the Velleman K4000, a system entry level would require a minimum of a specialist turntable or a two box CD player.

Does the amplifier represent value for money? Only you can decide this, but if you can justify spending this sort of money on an amplifier, then you owe it to yourself to investigate this one further.

I'm personally going to have to buy one to play with.

To be Continued...

Next month (can you wait that long?) I'll take a look at actually building the K4000 and pass on a few tips on the best way to make it sound good.

**A readers forum for your views and comments.
If you want to contribute, write to:**

**The Editor, 'Electronics – The Maplin Magazine'
P.O. Box 3, Rayleigh, Essex, SS6 8LR.**

Confused? You Will Be

Dear Editor,
I wonder whether it would be possible to improve the layout of mathematical formulae in your journal so that, for instance, equation 1 of Philip Lawton's article on page 45 of the January 1992 issue would appear as:

$$e = Ri + L \frac{di}{dt} + v$$

instead of being squashed into one line of print:

$$e = (R.i) + (L.(di/dt)) + v$$

as at present?

I find the latter, with its dots, strokes, and brackets- written-brackets, etc. confusing. The corresponding lines of the computer programs on page 47 of the same article look at first sight to be incorrect, but are in fact correct because of the literal way in which computers carry out arithmetic – so that, for instance, 'R/L*I' means 'divide R by L, then multiply the result by I' – i.e. (R/L)*I, not (R/L)I, would be assumed by a person not familiar with computers!
Mr. H Pursley, Surrey.

It would be really nice to write them out properly as you suggest, and indeed at one time this was managed. The actual typesetting required, however, is enormously complex and time consuming, but those were the old days when we only produced four magazines a year.

Nowadays there simply isn't always the time available. On average, if an article contains, say, six to eight or so complex equations, processing the equations alone (which must be done separately) can take up to four times as long as the whole of the rest of the article (honest), which is simply not on. A compromise had to be found, and hence the style currently shown. It has evolved to provide, as much as practicable, the fastest output of copy with the minimum setting time and subsequent number of corrections, with the least offence to mathematical sensibility. Some formulae, though, are determined to trip us up somehow! Roll on our forthcoming, new, all-singing all-dancing, networked DTP system, which (we hope) will produce 'proper' formulae in a twinkling of an eye!

Further Reading

Dear Editor,
Re the article 'Electronics In Aviation' by Chris Yates – good stuff this. I just thought that any of your readers whose appetites had been whetted by the mention of early radar work, might like to know of the fascinating account written by R.V. Jones about the work on British Scientific Intelligence 1939-45, etc. called 'Most Secret War', published as a paperback by Coronet paperbacks/Hodder

AIR YOUR VIEWS

STAR LETTER

This month Paul Wilson, from Aberdeen receives the Star Letter Award of a £5 Maplin Gift Token for his letter.



The World's First Dieting Catalogue

Dear Editor,
I have noticed increasingly over the past year how 'Constructors' Guide' leaflets have been littering my room. I wonder how I acquired them, then I came to the conclusion that they have all come with kits I have bought from Maplin. It seems that every kit rated 1–2 includes a 'Constructors' Guide'. This eleven page pamphlet may be helpful, or even essential, to the absolute beginner with a soldering iron in their hand, but to people like me, they just clutter up the place. Do we pay 25p for the 'privilege' of getting one of these with every kit purchased?

On a lighter note however, I discovered recently, when thumbing through my old 1991 Maplin catalogue, that it was in fact thicker than the new 1992 copy. I put the two together, and, sure enough it was a good few millimetres thicker. This struck me as odd, because the new catalogue had 48 more pages. Just to make sure, I weighed the two, which proved my argument; the 1991 catalogue weighs 104g, whereas the 1992 catalogue weighs 100g. Can you explain this miscarriage of 'logic'?

And now, a new idea for our 'Greener-than-Green Customers'! Send off your unwanted Constructors' Guides for recycling! Alternatively, go out and distribute

them amongst the uninitiated!

Seriously, you will be pleased to know that this item is supplied FREE with every kit, and so your 30p (it's gone up!) is still safe in your pocket. They are always supplied with all kits, because there is the reasonable possibility that the kit may be purchased by a new hobbyist or someone not acquainted with Maplin symbols and terminology.

Last year, a Mr. Bodger from Bromley put up a shelf to hold his prized collection of electronics manuals. However, due to the extra 4g weight (the 'straw that breaketh the camel's back') of a certain electronics catalogue, the shelf collapsed on him and bruised his head. On writing in with this sorry tale, we were happy to oblige with his request...

But seriously, well spotted! The catalogue is slightly lower in mass, and a few millimetres thinner – old Mr. Bodger might even get an extra book on his shelf, which will probably collapse again as a result! The main reason for these differences is that we're using a thinner paper to keep postal costs down (and therefore the price to our customers). In previous years we have actually printed the catalogue on two thicknesses of paper, normal for Maplin shops and branches of WHSMITH, and lightweight for mail order, but this itself caused confusion as you can imagine!

& Stoughton, and which reads like a good thriller. I discovered a copy whilst browsing (on holiday, like one does) and had great difficulty putting it down (I have no association with either the author or the publishers, by the way!) The ISBN number for the above is 0-340-241691, which may help if any of your readers want to get a copy.

G.J. Field, London.

Living by Numbers

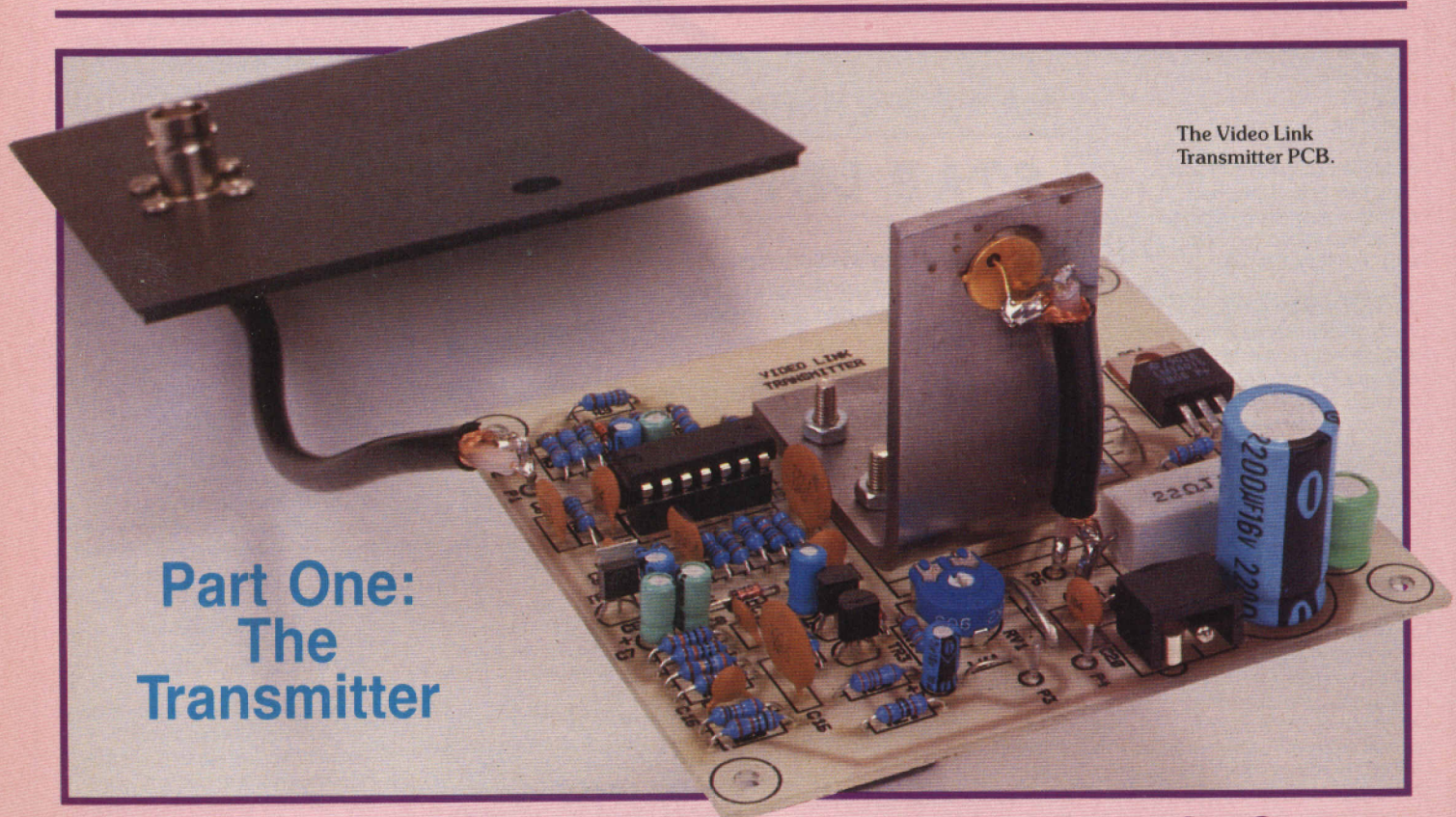
Dear Sir,
My thanks for the Magazine. I have bought most of the copies since the first, and I rate it highly. Most magazines are written by contributors whose concern is to sell the magazine, based, I am sure, on the assumption that most of the readers will not make up the projects, and if the things don't work we have 'sorry!' some months later. While the Maplin magazine is very readable, it seems to me that you are committed to making the projects work before you write an article about them, so that the articles are much more reliable. Thanks again. One small point on the Magazine. Most of the copies I have are dated and not numbered, so that a reference to 'Magazine No xx' is difficult to locate. Any help? Project: How about a unit which I can install in my car to give warning when I leave the car with the lights on? One which sounds when I open the door and the lights are switched on would do very nicely. It is a very simple unit, but the main problem is making it sufficiently neat, with a suitable case for installation.

**C.W. Morle,
Gerrards Cross, Bucks.**

Thank you for your kind comments – nice to know our hard work is appreciated! But enough of these niceties, and let us deal with your queries in the order in which they were raised! The point about the magazine references was raised over two years ago, when we started putting the reference numbers on the front cover of the magazine (this fact fans, started from Issue 34, or Oct/Nov 1989 in normalspeak!). However, the top of the contents page always features the issue number – if you wish, you could make up labels and stick them on the cover of magazines prior to that date. The main reason for adopting the system is that cross-referencing is much easier – and it makes ordering back issues of 'Electronics' a lot easier (the order code for a particular copy is XA followed by the issue number). As for what happens after Issue 99, your guess is as good as mine! Finally, I hope that you are pleased with Joe Fuller's 'Lights-On Reminder' article, published in last month's (Issue 50) 'Electronics'. What a fortunate coincidence!

INFRA-RED VIDEO LINK

B Y G A V I N C H E E S E M A N



Part One: The Transmitter

FEATURES

- ★ Range up to 100m
- ★ 12V operation
- ★ Replaces long video cables

APPLICATIONS

- ★ Point-to-point video link
- ★ Security
- ★ General Communications

The Infra-Red Video Link allows the transmission of monochrome composite video over a distance of up to 100 metres. The system makes use of large Fresnel lenses to focus the infra-red energy at much greater distances than are possible using standard techniques.

Circuit Description

Figure 1 shows the circuit diagram of the transmitter. The power supply is connected via SK1. Diode D1 provides reverse-polarity protection. The circuit requires two separate supply rails: a 12V, high current

| | |
|----------------------------------|-------------------|
| Power Supply Voltage | 12V to 14V |
| Power Supply Current (Quiescent) | 150mA at 12V |
| Range | Up to 100m |
| PCB Dimensions | 83 × 83mm approx. |
| Focal Length of Lens | 270mm approx. |
| Peak Infra-red Wavelength | 940nm |
| Composite Video Input | 1V peak-to-peak |
| Video Bandwidth | 4MHz |

Table 1. Prototype Specification.

supply; and a 5V, low current supply. Regulator RG1, with its associated components, provides the regulated 5V supply for IC1. A composite video signal, at a standard 1V peak-to-peak level, is applied to the circuit between P1 and P2.

A video signal essentially consists of three parts; synchronisation (sync) pulses, a luminance (brightness) signal, and chrominance (colour) information. The circuit makes use of only the sync and luminance components; for practical purposes, the chrominance signal can be ignored. Separating the sync and luminance signals allows each of these to be

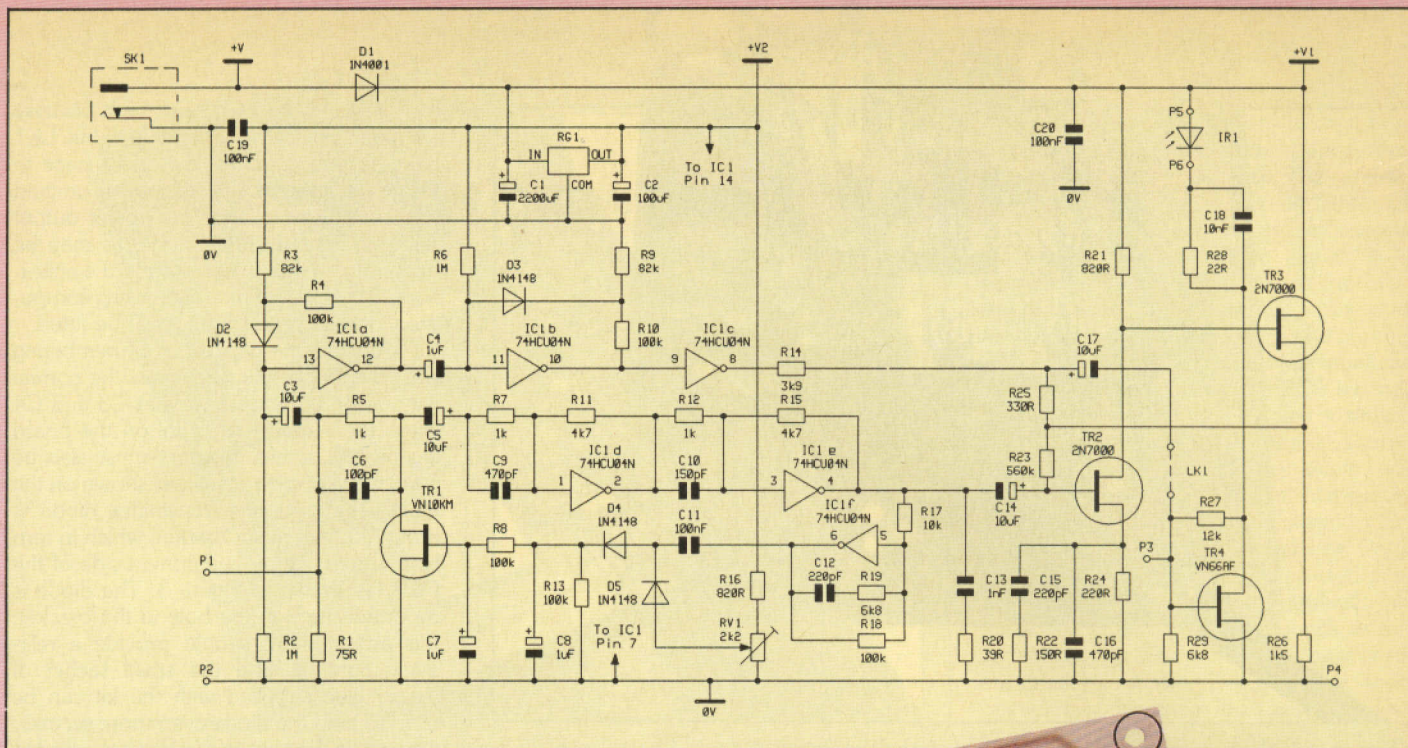


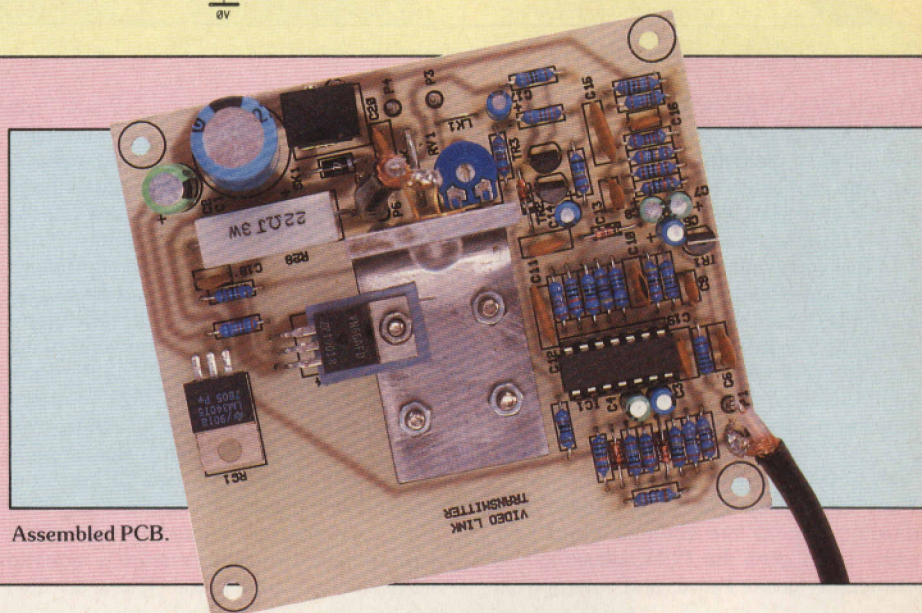
Figure 1. Circuit diagram.

handled separately, as each requires different processing.

The high frequency luminance signal is separated and processed by IC1d and e. It is necessary for the overall gain of the circuit to peak at high frequencies to compensate for the poor response of the infra-red emitter at higher frequencies. Capacitors C6, C9 and C10 provide high frequency peaking.

The sync signal is processed by IC1a, b and c to remove the high frequency luminance signal, and to produce clean frame and line sync pulses.

IC1f forms part of an AGC (automatic gain control) amplifier. The output from



Assembled PCB.

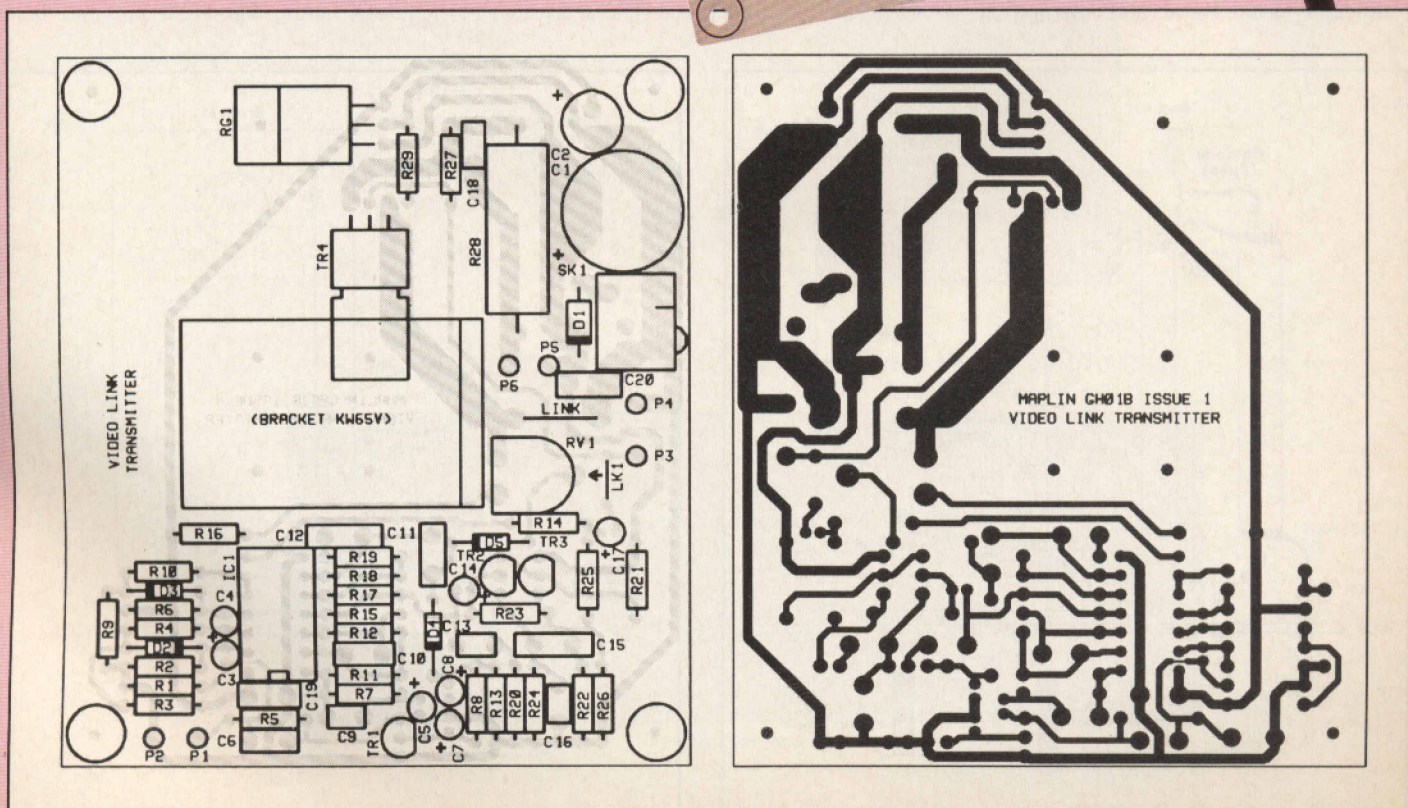
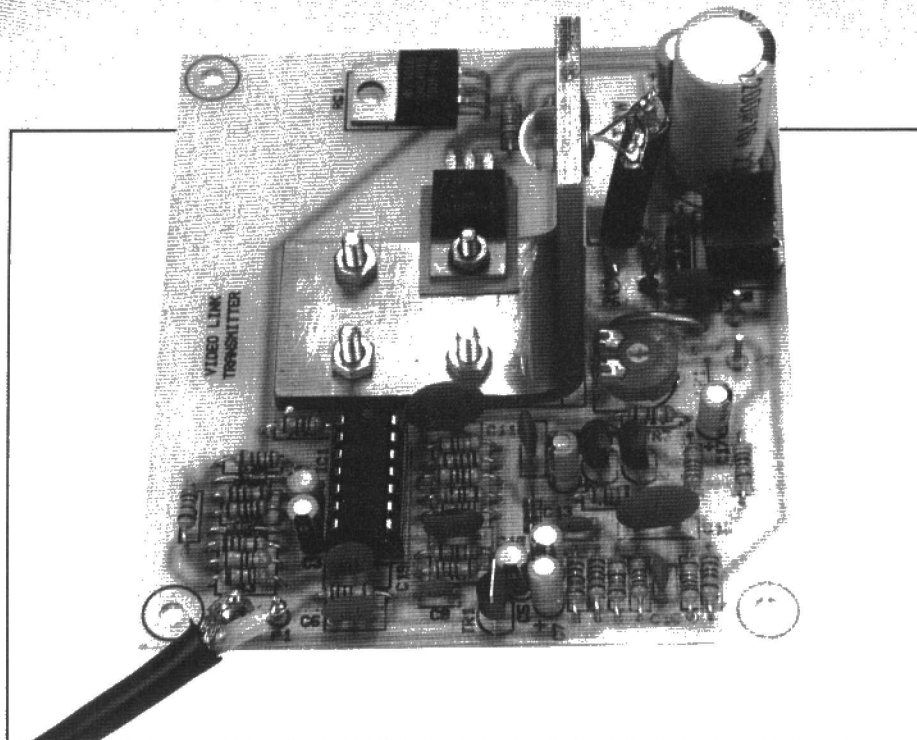


Figure 2. PCB legend and track.



Close-up of PCB, showing mounting (and wiring) of infra-red emitter.

this stage is rectified by D4 and fed to TR1, which maintains a relatively constant signal in the system, helping to prevent overloading. Preset resistor RV1 adjusts the AGC level, and indirectly controls the output level of the transmitter.

The sync and luminance signals are recombined after processing, and are fed to output transistor TR4, which drives the high power infra-red emitter, IR1. IR1 is positioned at approximately the focal length of a large Fresnel lens such that the infra-red energy is focused to infinity.

Construction

After identifying the components and ensuring that all are present, insert and solder them onto the PCB, following the instructions given below and referring to

the legend shown in Figure 2. If you have had little, or no, experience of electronic project construction, then please refer to the Constructors' Guide (included with the kit), for useful practical information.

Start assembly by fitting the resistors, as these are fairly low profile components which may be difficult to fit at a later stage in construction. When fitting the IC socket, make sure that the notch at one end of the socket corresponds with that on the PCB legend; do not fit the IC until all other components have been soldered in place.

The PCB pins should be fitted next, these being inserted into the PCB and then pressed home using a hot soldering iron. When the pins are heated to the correct temperature, very little pressure is required to push them into place. There are two

wire links on the PCB, and both of these are fitted in normal operation. Link LK1 connects the output of the driver stage to the power output stage and may be omitted if it is required to drive the power output stage directly via P3 and P4, as may be necessary in some non-standard applications. For standard operation using composite video, however, LK1 must be fitted.

Next, fit the capacitors, remembering to fit the electrolytic capacitors the correct way around. Please note that C3 and C4 share the same '+' symbol on the board legend. All semiconductors must also be fitted with correct polarity, as shown on the PCB. The infra-red transmitter diode is mounted on a metal bracket, which in turn is mounted on the component side of the PCB, as shown in Figure 3. The diode is mounted through the hole in the bracket; this arrangement should provide a relatively tight fit, and the small sachet of epoxy glue supplied with the kit can be used to hold the diode even more securely in position. Four nuts and bolts are used to fasten the bracket to the PCB. The diode is wired onto P5 (anode) and P6 (cathode) on the PCB, using the screened cable supplied. The leads of the diode should be cut to 10mm and bent in such a way as to reduce the possibility of shorting. Sleeving may also be used if necessary, but the leads of the diode are comparatively rigid and should stay apart once correctly positioned.

The transistors (and regulator RG1) are fitted so that their cases correspond with the relevant outlines on the PCB. A hole is provided on the PCB, allowing the regulator to be bolted to the PCB using an M3 nut and bolt; however, this is optional and it is not essential to do this. TR4 uses the diode bracket as a heatsink to aid heat dissipation, and is mounted as shown in Figure 4, using the M2.5 nut and bolt

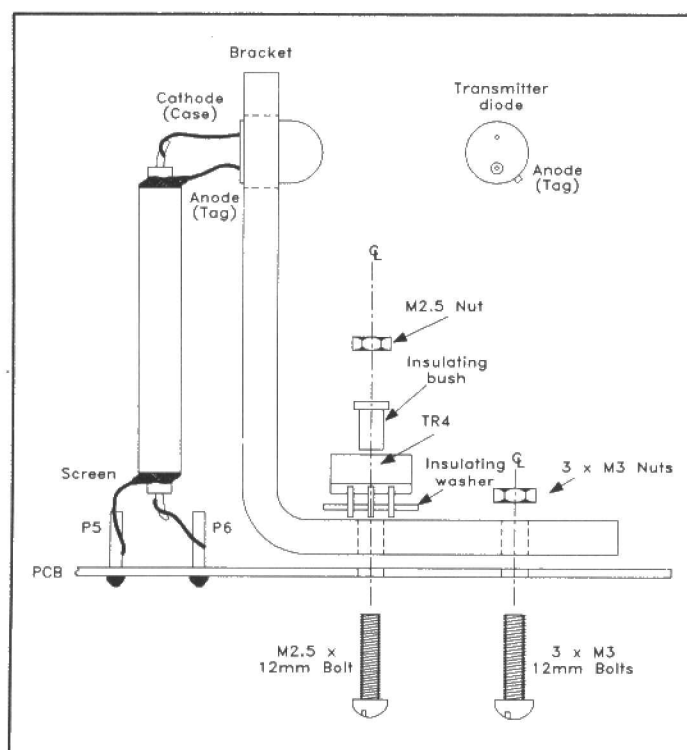


Figure 3. Mounting the emitter diode and diode bracket.

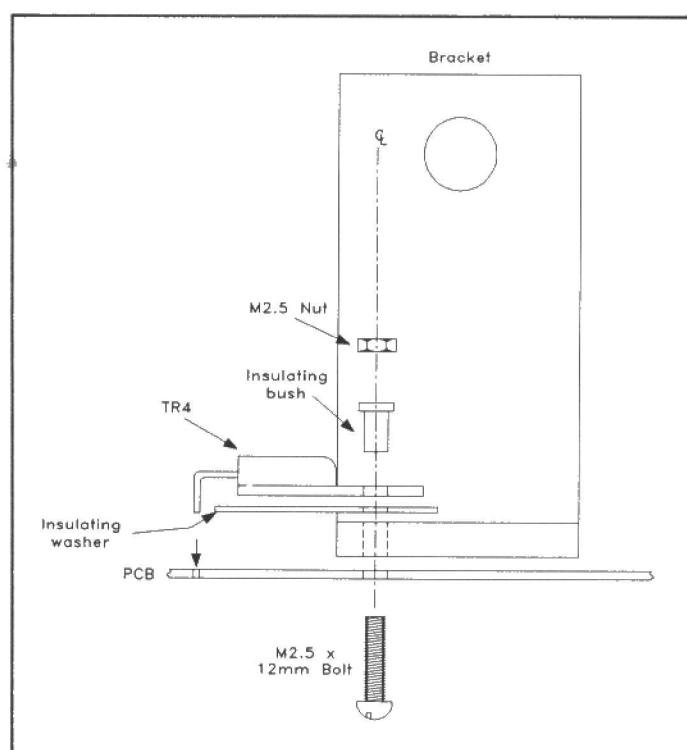
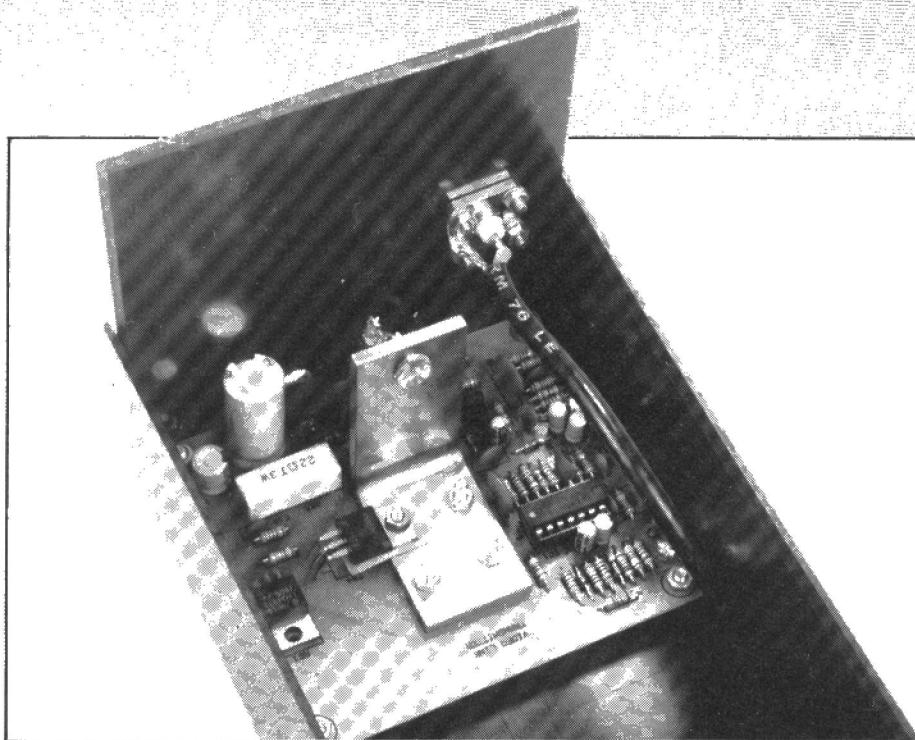


Figure 4. Mounting TR4 onto the bracket.



Infra-Red Video Link transmitter with top lid removed, showing internal assembly detail.

supplied in the kit. Please note: the transistor needs to be insulated from the bracket with an insulating bush and a greaseless washer.

Testing

Before applying power to the circuit, it is recommended that you double-check your work to ensure that all of the components are fitted correctly, and that there are no dry joints or solder bridges. Power supply connections are made via a PCB-mounted 2.5mm power socket; the outer part of the power plug should be connected to 0V,

and the inner part to +V. The circuit requires a 12V to 14V DC power supply capable of supplying at least 500mA. Although the module has its own on-board regulation and decoupling components, it is recommended that a power supply with a suitably smooth output is used to prevent any unwanted modulation of the supply rails. A suitable power supply for the unit is YZ21X. The composite video input signals are applied to P1 (input), and the return (ground) to P2 (0V), via the BNC input socket. The input signal level should be approximately 1V peak-to-peak.

It is not possible to test the unit fully without the appropriate infra-red receiver, or a full set of test equipment. The receiver will be detailed in the next issue of 'Electronics'. If you have an oscilloscope set up to display a video signal, it is possible to make basic tests on the unit. Apply a video signal to the input, and monitor the signal between P3 and ground (P4). Set RV1 to the centre of its travel, as marked by the arrow on the PCB legend. The oscilloscope should display a similar waveform to that of the original source video signal, although the levels will probably be different. The waveform displayed is that of the drive signal to the power output stage. If the signal on P6 is monitored, a somewhat compressed version of the signal should be displayed on the scope screen; this corresponds to the voltage across IR1. Although these tests are relatively simple, they allow the basic operation of the circuit to be assessed. The setting of preset RV1 depends on the location of the transmitter and receiver, and should be left until both units are in place and the system is up and running.

Housing

An undrilled case is supplied in the kit, to house the transmitter. The drilling details are shown in Figure 5. The box has slots to hold the Fresnel lens in place. In each case, the PCB is mounted using 4 × M3 nuts and bolts. ¼in. spacers are used to position the PCB at the correct height in the case. The PCB is mounted such that the vertical part of the 'diode bracket' is positioned 270mm from the lens (as

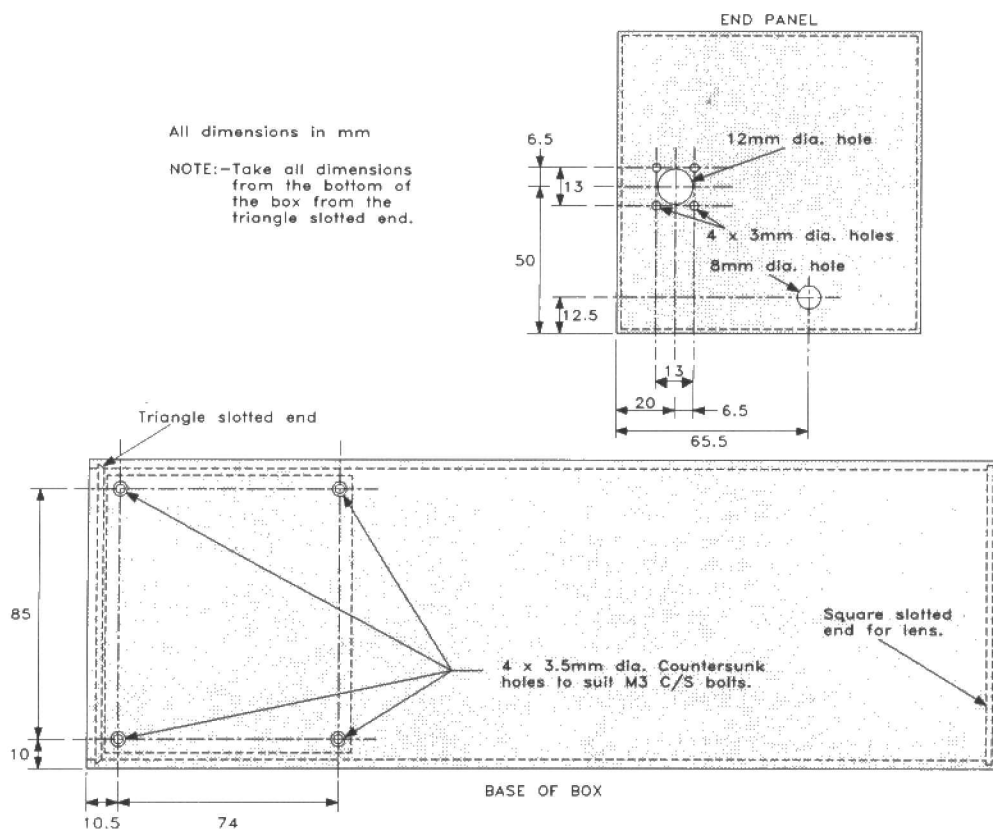
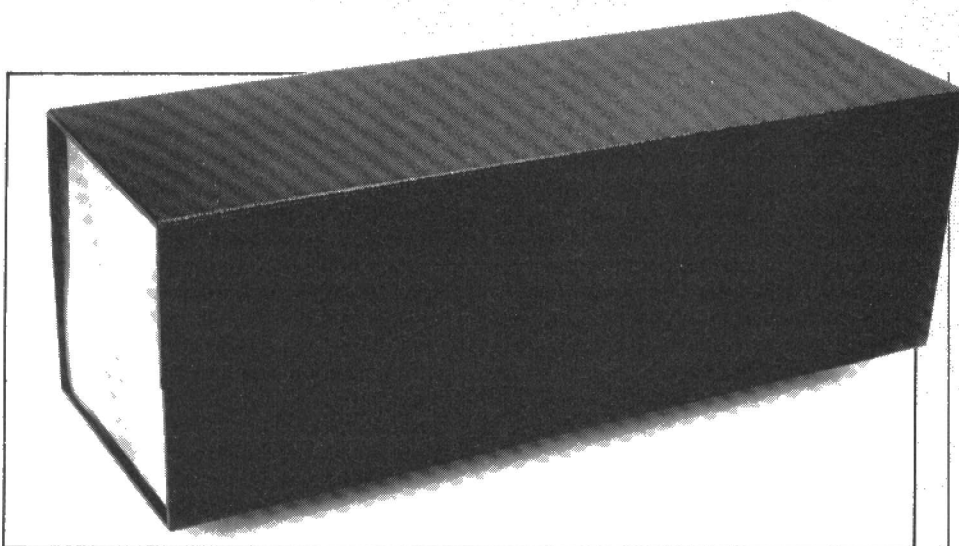


Figure 5. Drilling details.



Front of unit, showing mounting of Fresnel lens.

accurately as possible); this is approximately the focal length of the lens and has been found to provide the optimum range. Figures 6 and 7 show how to mount the lens and PCB in the case (see note below). The input (BNC) socket, SK2, is mounted on the rear panel, and is wired to the PCB. The power socket (SK1) does not require any additional wiring, being PCB mounted. It is, however, necessary to drill a suitable hole in the rear panel of the box to allow a 2.5mm power plug to be inserted.

The Fresnel lens, as supplied, is too large to fit into the end of the box supplied in the kit, and a box to hold a lens of this size would not be practical in many cases. It is therefore necessary to cut the lens to the correct size to fit into the box, and this is 103mm x 103mm. It is important that the lens is cut as carefully and accurately as

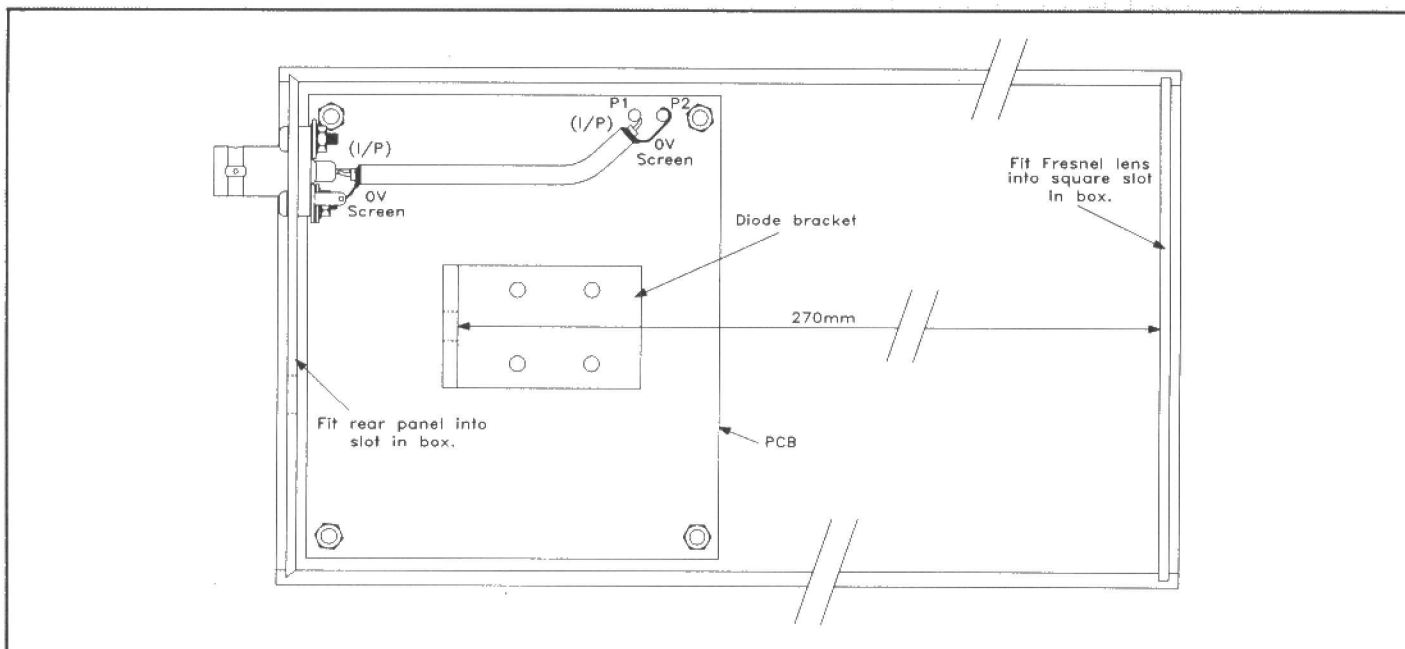


Figure 6. Positioning the PCB and wiring SK2.

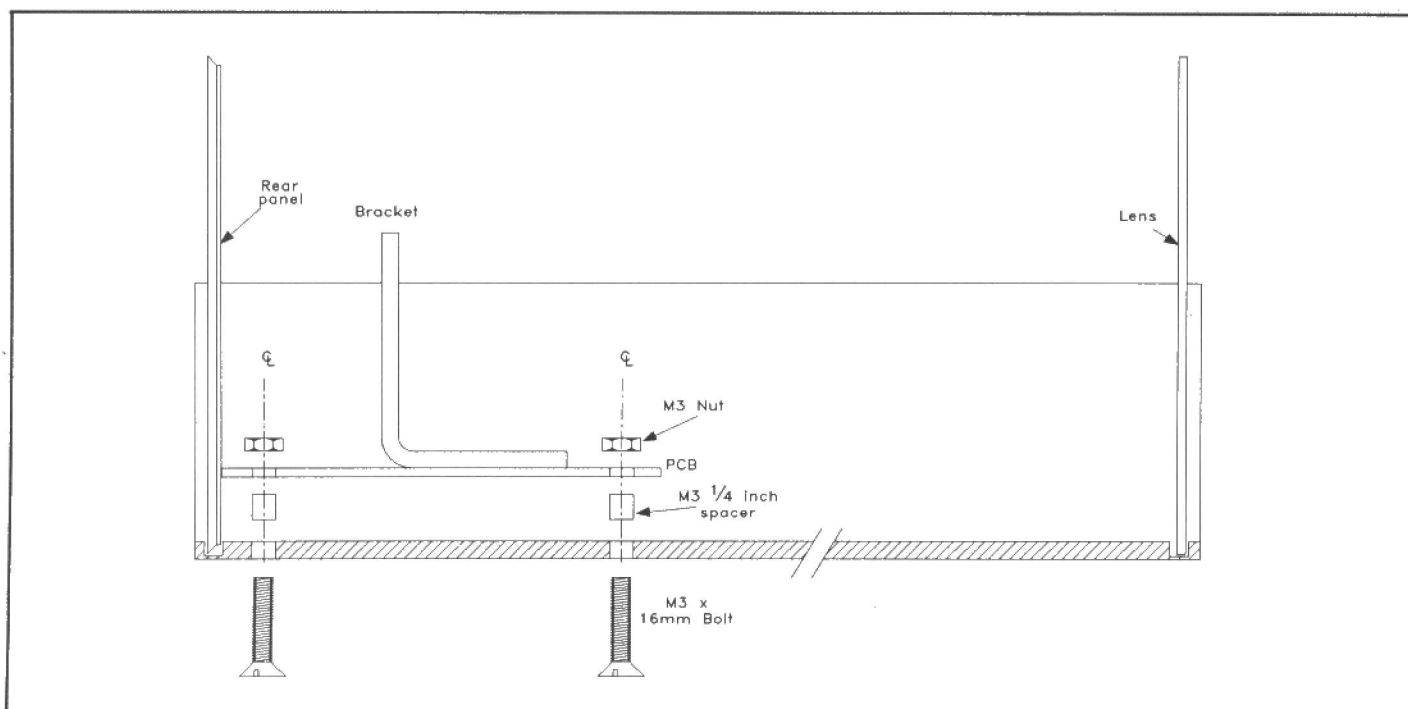


Figure 7. Mounting the PCB, lens and rear panel.

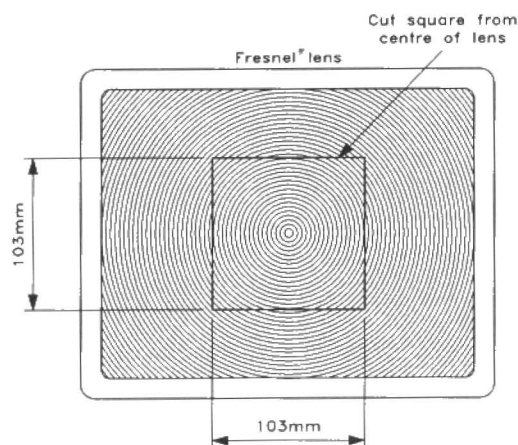


Figure 8. Cutting the Fresnel lens.

possible to ensure a correct fit. In addition, when trimming the lens down to size, material should be cut equally from the four sides so that the central point of the concentric rings is in the centre of the square, as shown in Figure 8. The box is not resistant to water and if the system is used outdoors, a degree of waterproofing will be necessary. This may be achieved by smearing a thin layer of silicone rubber

sealant around all of the box joints, including the grooves for the lens and the rear panel. A suitable sealant is YJ91Y. It is recommended that where possible, the unit is mounted in a sheltered location.

Mounting Considerations

It is necessary to provide a secure mounting point for the transmitter and receiver units. This may be achieved in a

variety of ways; one method, used for the prototype, makes use of small speaker stands (stock code GL18U), which are supplied in a pack of 2 with a selection of different types of bracket. The stands are particularly useful as they allow the bracket to be moved freely for alignment purposes, and also clamp securely in place when alignment is complete. There are obviously many different methods of mounting the transmitter and receiver units, and the most suitable method must be chosen for each individual situation.

It is important that the finished transmitter is NOT pointed directly at the sun, as the lens could focus the sun's rays onto the PCB, emitter diode or associated components, generating heat and causing irreparable damage. This consideration may dictate where the unit is mounted, and in problem cases it may prove beneficial to devise a protective hood for the front of the unit, to shield the lens from direct sunlight.

Next Month

In the April edition of 'Electronics', we will give full details of construction for the matching receiver unit.

INFRA-RED VIDEO LINK TRANSMITTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless specified)

| | | | |
|---------------|----------------------|---|---------|
| R1 | 75Ω | 1 | (M75R) |
| R2,6 | 1M | 2 | (M1M) |
| R3,9 | 82k | 2 | (M82K) |
| R4,8,10,13,18 | 100k | 5 | (M100K) |
| R5,7,12 | 1k | 3 | (M1K) |
| R11,15 | 4k7 | 2 | (M4K7) |
| R14 | 3k9 | 1 | (M3K9) |
| R16,21 | 820Ω | 2 | (M820R) |
| R17 | 10k | 1 | (M10K) |
| R19,29 | 6k8 | 2 | (M6K8) |
| R20 | 39Ω | 1 | (M39R) |
| R22 | 150Ω | 1 | (M150R) |
| R23 | 560k | 1 | (M560K) |
| R24 | 220Ω | 1 | (M220R) |
| R25 | 330Ω | 1 | (M330R) |
| R26 | 1k5 | 1 | (M1K5) |
| R27 | 12k | 1 | (M12K) |
| R28 | 22Ω 3 Watt Wirewound | 1 | (W22R) |
| RV1 | 2k2 Hor Encl Preset | 1 | (UH01B) |

CAPACITORS

| | | | |
|------------|---------------------|---|---------|
| C1 | 2200μF 16V PC Elect | 1 | (FF60Q) |
| C2 | 100μF 16V Minelect | 1 | (RA55K) |
| C3,5,14,17 | 10μF 16V Minelect | 4 | (YY34M) |
| C4,7,8 | 1μF 63V Minelect | 3 | (YY31J) |
| C6 | 100pF Ceramic | 1 | (WX56L) |
| C9,16 | 470pF Ceramic | 2 | (WX64U) |
| C10 | 150pF Ceramic | 1 | (WX58N) |
| C11,19,20 | 100nF Disc | 3 | (YR75S) |
| C12,15 | 220pF Ceramic | 2 | (WX60Q) |
| C13 | 1000pF Ceramic | 1 | (WX68Y) |
| C18 | 10000pF Ceramic | 1 | (WX77J) |

SEMICONDUCTORS

| | | | |
|----------|-------------------|---|---------|
| IC1 | 74HCU04N | 1 | (UB04E) |
| RG1 | μA7805UC | 1 | (QL31J) |
| TR1 | VN10KM | 1 | (QQ27E) |
| TR2,3 | 2N7000 | 2 | (UF89W) |
| TR4 | VN66AF | 1 | (WQ97F) |
| D1 | 1N4001 | 1 | (QL73Q) |
| D2,3,4,5 | 1N4148 | 4 | (QL80B) |
| IR1 | I/R Photo Emitter | 1 | (KW66W) |

MISCELLANEOUS

| | | | |
|-------|-----------------------|--------|---------|
| P1-P6 | Pin 2145 | 1 Pkt | (FL24B) |
| | DIL Socket 14 Pin | 1 | (BL18U) |
| | PCB | 1 | (GH01B) |
| SK2 | BNC Square Socket | 1 | (YW00A) |
| SK1 | PCB 2.5mm DC Pwr Skt | 1 | (FK06G) |
| | I/R Video Case | 1 | (GL48C) |
| | Fresnel Lens (Large) | 1 | (KW60Q) |
| | Bracket | 1 | (KW65V) |
| | Insulator TO220 | 1 | (QY45Y) |
| | Plastic Bush TO66 | 1 Pkt | (JR78K) |
| | Low C Cable | 1m | (XR19V) |
| | TC Wire 16swg 1.6mm | 1 Reel | (BL11M) |
| | Poziscrew M3×16mm | 1 Pkt | (JC70M) |
| | Steel Nut M3 | 1 Pkt | (JD61R) |
| | Steel Screw M2.5×12mm | 1 Pkt | (JY31J) |
| | Steel Nut M2.5 | 1 Pkt | (JD62S) |
| | Steel Screw M3×12mm | 1 Pkt | (JY23A) |
| | Double Bubble Sachet | 1 | (FL45Y) |
| | Spacer M3×1/4in. | 1 Pkt | (FG33L) |
| | Instruction Leaflet | 1 | (XK44X) |
| | Constructors' Guide | 1 | (XH79L) |

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LP59P (I/R Video Link TX Kit) Price £39.95.

Please note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1992 Maplin Catalogue.

Video Link TX PCB Order As GH01B Price £3.45.

I/R Video Case Order As GL48C Price £14.95.

Fresnel Lens (Large) Order As KW60Q Price £9.95.

Bracket Order As KW65V Price £2.45.

CIRCUIT MAKER

Circuit Maker is a forum for readers' circuits, ideas and tips. The circuits and information presented here must be considered as a basis for your own experimentation, no warranty is given for suitability in particular applications, reliability or circuit operation. Maplin cannot support, in any way, the information presented here. However, where possible, we will endeavour to check that information presented, is correct, and that circuits will function as stated. If you would like your ideas to be considered for inclusion in Circuit Maker, please mark your submission 'Circuit Maker' and send it to: The Editor, 'Electronics - The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR.

Live-Wire Bargraph by Robert Elliott

This simple, add-on circuit expands the Maplin Live-Wire Detector (recently featured in the December 1991 issue of 'Electronics'), providing a bargraph display bright enough to be seen in the strongest of working light levels. It is based on the original Maplin circuit, basically a highly efficient design, which remains unchanged.

The problems with the original unit are that the glow of the original LED (LD1) may not easily be seen even in normal room lighting, and that the buzzer does not sound until the LED has almost reached full brightness.

The Live-Wire Bargraph enables the first, faint glow of the LED to be translated into a fully-lit first segment on the display. The remaining segments will light in a 'dot' mode, changing to a 'bar' mode (with all ten segments lit) when the unit is at its closest to the cable. As a result, we also have an indication of distance from the cable. At this point, the buzzer (if left in circuit) will sound, providing an audible verification. Of course, it is not possible to equate a particular segment with a precise distance, as field

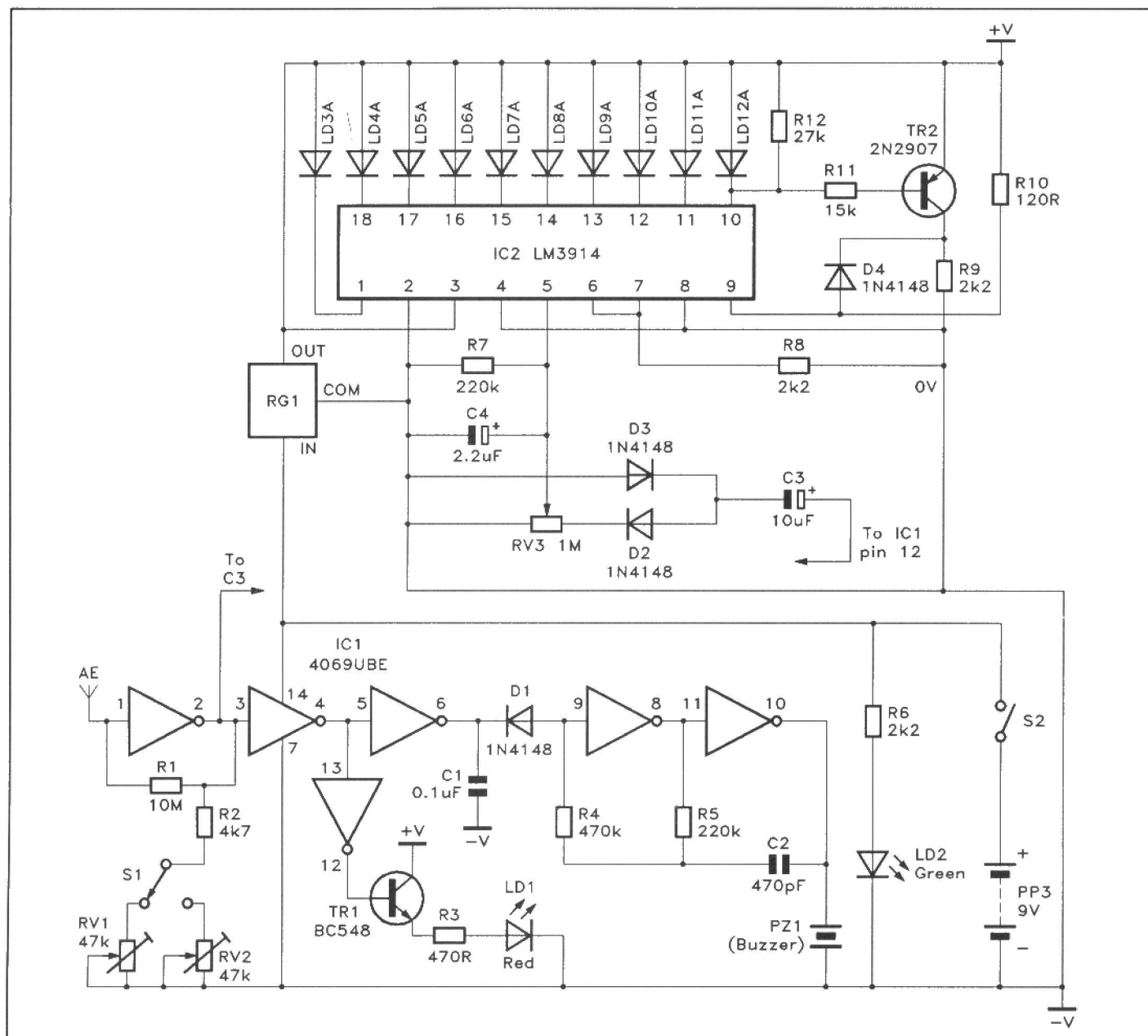
strengths vary considerably, but such a facility is useful nevertheless.

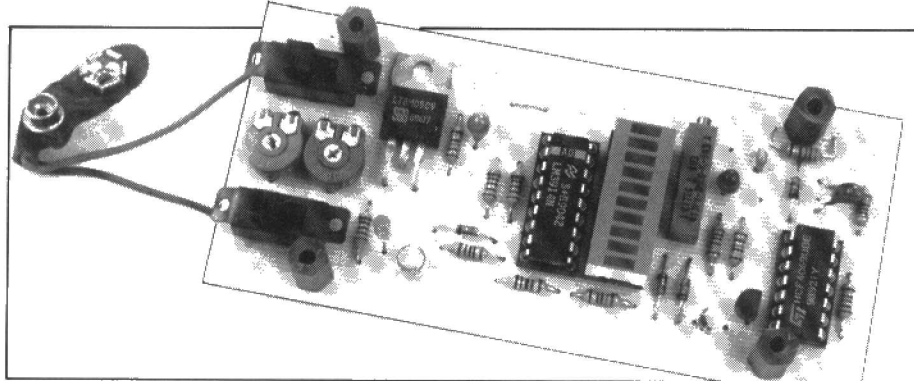
A two-position range switch, which selects between high and low sensitivity, increases the flexibility of the unit. A low sensitivity is necessary in situations where complex electro-magnetic fields exist. An example of this is where a number of similar cables run in proximity to each other, but an individual cable needs to be tested.

The only changes made to the original circuit are the addition of a second preset, and an increase in aerial length (to 50mm; on the prototype this track is 2mm wide). The two individually adjusted presets are switched into circuit by the sensitivity (range) switch.

Circuit Description

This description covers the modifications; for the rest of the circuit, the reader is referred to issue 48 (Dec '91) of 'Electronics'. Any AC electromagnetic field present induces a voltage on the track, which is connected to pin 1 of IC1. As a result, a voltage increase occurs at pin 12. This voltage is fed to the bargraph driver, IC2, which acts as a voltmeter. A change of as little as 0.3V at





pin 12 of IC1 will produce a change of one segment on the bargraph display. The actual voltage range is approximately 1.0V (with LD1 completely unlit), to 3.8V (when all segments of the bargraph, LD3A to 12A, are fully lit).

The signal voltage from IC1 pin 12 is supplied, via C3, to a charge pump comprising D2 and D3. RV3 controls the strength of the signal to pin 5 (the input) of IC2, and is adjusted so that when LD1 reaches maximum brightness, all ten segments are just fully lit.

Display brightness is determined by R8, and the value chosen gives maximum brightness. Increasing the value of R8 would produce a dimmer display, but prolong the life of the battery.

IC2 pins 4 and 8 are used to determine the voltage at which the first segment of the bargraph will light. By grounding them as shown, the first segment will light as LD1 is beginning to glow.

The level of display damping is controlled by C4. The absence of a capacitor here would make the display too unsteady to be useful. C4 is included to simply slow down the response rate of the driver IC to any fluctuations in the voltage supplied by IC1 pin 12. This damping capacitor therefore enables a steady display to be produced, rising and falling smoothly in relation to the unit's distance from the live cable.

IC2, a LM3914 device, is capable of operating in either dot or bar mode. If pin 9 is connected to the positive rail, bar mode is selected; if it is left floating, the device will operate in dot mode. The circuit has been designed so that dot mode is operational when segments LD3A to 11A light up.

However, when the tenth segment (LD12A) glows, then so do the rest, the bar mode coming into operation at that point. This arrangement not only provides a graphic indication that full scale has been reached, but also extends battery life (only one segment is lit unless the electromagnetic field is extremely strong – a relatively rare occasion).

When segment 10 lights, TR2 starts to conduct, effectively connecting pin 9 to the positive rail and thereby switching IC2 to bar mode. LD1 is used when setting up the bargraph, and need not be visible when the circuit is housed.

The voltage regulator ceases to function correctly when the supply voltage falls below 7.0V and therefore a new battery should be used when setting up the unit. A non-uniform bargraph display is evidence that the battery voltage has fallen too low. If the brightness of LD1 does not vary smoothly in operation, immediately suspect IC1 and replace accordingly. Another symptom of a possible fault within IC1 is that LD1 will not turn off when removed from the electromagnetic field, having reached full brightness.

In the event that a very non-linear readout (with respect to distance from the electromagnetic field) occurs, or it is difficult to get full scale with the unit (at its most sensitive setting) placed two inches from the cable, a low resistance (around 100 to 500Ω) should be placed between IC2 pins 4/8, and ground. It is a simple matter to break the track, and solder in the resistor on the reverse side of the board should this be necessary. This resistance has the effect of increasing the voltage at which the first segment lights, although it is actually shifting

the voltage range over which the bargraph is operating. Its value can be determined by experiment. Alternatively, a variable resistor of, say, 1kΩ can be inserted. This is adjusted in tandem with RV3 to achieve the desired display range.

Setting Up

After building up the circuit on stripboard, or a home-etched PCB, the unit should be built into an enclosure, to protect the PCB and battery. An ideal choice would be a transparent box (e.g. YU94C) so that all indicators could be visible to the outside world. The buzzer, if present, could be secured to the upper half of the box with double-sided sticky tape, positioned above IC1.

Because of body interaction with the circuit, setting up is best done with the PCB mounted in the box, and holes should be drilled providing access to RV1, RV2 and RV3. The unit should be set up in a dimly lit room.

Set S1 to the low sensitivity position, connect up the battery and switch on S2. The bargraph may, or may not, light at this stage. LD2 (green) should glow, however. Adjust RV1 so that LD1 just lights when about 6in. away from a live cable. At this point, the first segment of the bargraph should be lit. When the unit is held directly against the cable, LD1 should be fully lit. Adjust RV3 so that all of the ten segments of the bargraph are just lit. Advancing RV3 too far beyond this point may cause the bargraph to hold at full scale, even when the unit is removed from the electromagnetic field.

Switch S1 to the upper position (high sensitivity), and adjust RV2 so that LD1 just begins to glow at about 12 to 18in. from the cable. Full scale on the bargraph should be achieved when the Live-Wire Bargraph is located at a distance of between 1 and 2in. from the cable.

To demonstrate the unit's reaction to greater field strengths, take it with you in the car and drive under some overhead National Grid cables. When set to high sensitivity, the bargraph display should move smoothly up and down as you go under and away from the cables.

PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless specified).

| | | | |
|--------|--------------------------|---|-------|
| R1 | 10M 5% Carbon Film 1/3W | 1 | B10M |
| R2 | 4k7 | 1 | M4K7 |
| R3 | 470Ω | 1 | M470R |
| R4 | 470k | 1 | M470K |
| R5,7 | 220k | 2 | M220K |
| R6,8,9 | 2k2 | 3 | M2K2 |
| R10 | 120Ω | 1 | M120R |
| R11 | 15k | 1 | M15K |
| R12 | 27k | 1 | M27K |
| RV1,2 | 47k Hor. Enclosed Preset | 2 | UH05F |
| RV3 | 1M 18-Turn Cermet Preset | 1 | UH29G |

CAPACITORS

| | | | |
|----|-----------------------|---|-------|
| C1 | 0.1μF 35V Tantalum | 1 | WW54J |
| C2 | 470pF Ceramic | 1 | WX64U |
| C3 | 10μF 16V Electrolytic | 1 | YY34M |
| C4 | 2.2μF 35V Tantalum | 1 | WW62S |

SEMICONDUCTORS

| | | | |
|-----|-------|---|-------|
| TR1 | BC548 | 1 | QB73Q |
|-----|-------|---|-------|

| | | | |
|-----------------|-------------------------------|---|-------|
| TR2 | 2N2907 | 1 | QR19V |
| D1,2,3,4 | 1N4148 | 4 | QL80B |
| IC1 | 4069UBE | 1 | QX25C |
| IC2 | LM3914 | 1 | WQ41U |
| LED1 | Red 3mm LED | 1 | WL32K |
| LED2 | Green Cylindrical LED | 1 | YH73Q |
| LED1A to LED10A | Red 10 Segment Bargraph Array | 1 | BY65V |
| RG1 | μA78M05UC | 1 | QL28F |

MISCELLANEOUS

| | | | |
|-------|-------------------|---|-------|
| S1,S2 | Sub-min Slide | 2 | FH35Q |
| B1 | Alkaline PP3 | 1 | FK67X |
| | Battery Clip | 1 | HF28F |
| | 14-pin DIL socket | 1 | FJ64U |
| | 18-pin DIL socket | 1 | FJ66W |
| | 20-pin DIL socket | 1 | FD90X |

OPTIONAL

| | | | |
|-----|----------------------------|------|-------|
| PZ1 | Mini Sounder | 1 | FM59P |
| | Transparent Box | 1 | YU94C |
| | Spacers | 1Pkt | FE69A |
| | Self-Tappers No.4 × 1/4in. | 1Pkt | FE68Y |

ELECTRONICS

IN

AVIATION

Part Three Communication

by Chris Yates

During the post-war years the United Kingdom aviation scene grew in leaps and bounds, whilst alongside it developed one of the most advanced communication networks in the world. The heart of this system is the VHF and UHF radio telephone (RT) service, operated on behalf of National Air Traffic Services by the Civil Aviation Authority (CAA). To communicate with domestic ATC controllers civil aircraft use frequencies from 118 to 137MHz, and their military counterparts have an allocation from 225 to 399.9MHz.

The civil band has recently been extended to provide for the growing needs of air-traffic control, and both allocations are unusual in that all transmissions are Amplitude Modulated. At both VHF and UHF the mode of operation is Simplex – in other words both aircraft and ground use the same frequency, but only one can transmit at any one time. Simplex operation is illustrated in Figure 1.

Sectors

As discussed last month, the country is divided into geographic sectors, and at peak times each is handled by an individual controller via its own frequencies. However, one of the unusual features of this network is its ability to 'band box' sectors. A facility used extensively at night, it allows one controller to communicate simultaneously on several different frequencies. This is illustrated in Figure 2.

It also means that transmissions received at any one station in the chain are re-broadcast by others. In this way 'night-owl' airband enthusiasts can often follow the progress of a flight without tuning away from the best heard ground station.

Range

The main disadvantage of VHF and UHF operation is range. Above about 50MHz the ionosphere does not normally enhance the reach of radio signals, so transmissions are often limited to little more than line of sight, see Figure 3. Whilst this radio horizon for high flying aircraft may well be several hundred miles distant, ground stations are presented with a wholly different set of circumstances. Mountains, hills and even buildings all serve to impair their coverage area, so to achieve the fullest possible service over the whole country, the CAA operate a network of eighteen remote transmit/receive sites which are dedicated to airways control.

Where it is not possible to obtain full coverage with one transmitter a

number are used, all radiating on the same centre frequency but 'offset' from one another by a few kilohertz. The net effect is a full service without the need to change channel, as can be seen in Figure 4. These remote stations are linked to the London, Manchester and Prestwick ATC centres via landlines, and provide a VHF and UHF radio telephone service over the whole of the United Kingdom and surrounding seas.

Airports

The second tier to this communication network centres upon individual airports. However, with the need to cover vast distances removed, the transmission footprint is tailored to suite local requirements. In practice, this means a range that is rarely in excess of fifty miles, indeed, it is often the case that a ground based receiver cannot hear local aero-

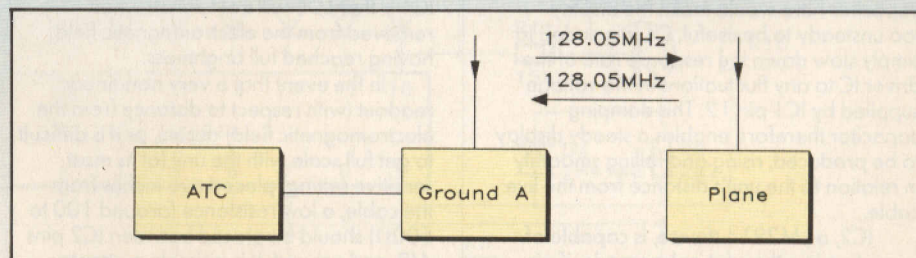


Figure 1. Basic Simplex operation.

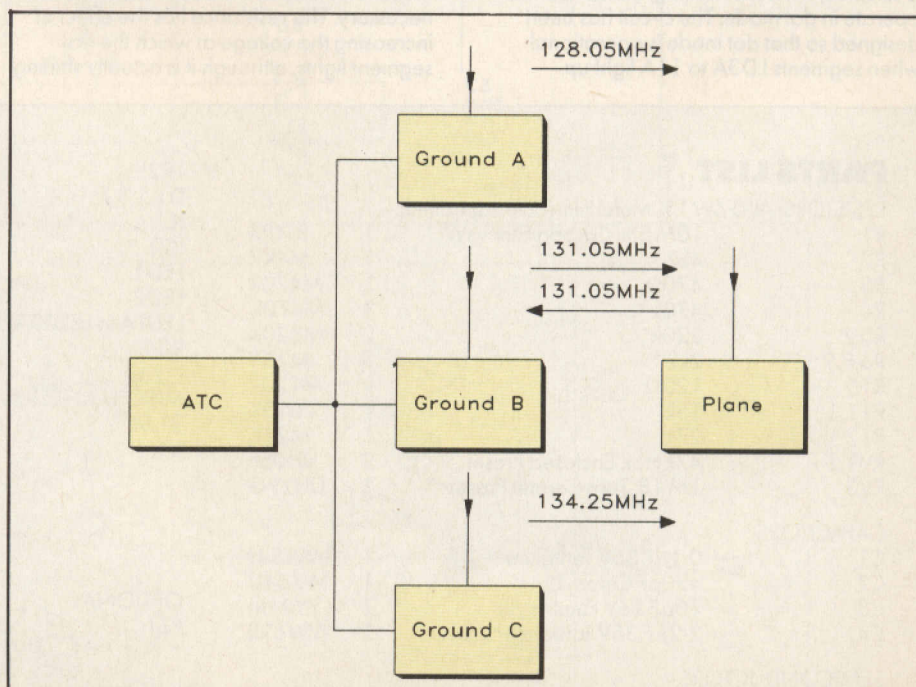


Figure 2. Banded Sector simplex. In this system transmission made on Ground B frequencies are re-broadcast by A and C. Likewise those made on Ground A would be heard on B and C, and on C by A and B.

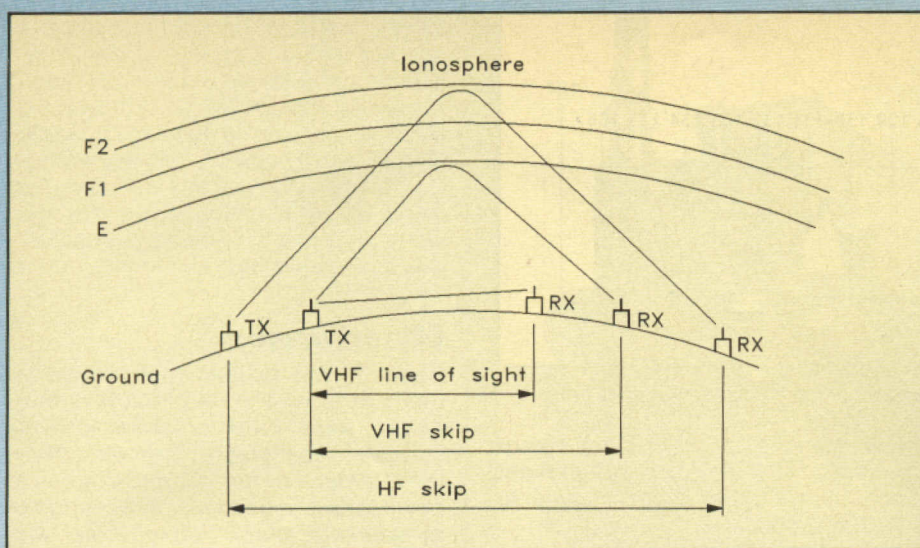


Figure 3. HF signals are propagated by the ionosphere F1/F2 layers and travel great distances. Under exceptional circumstances VHF transmissions bounce off the E-layer, but these normally travel only by line of sight.

drome RT even ten or fifteen miles away. Typically the RT service is used for Approach and Radar control, landing and take-off clearance via the Tower, and Ground Movement communications.

Allocations

Within the civil aviation band, allocation of frequencies is a fairly logical affair. As a general rule of thumb it can be divided into three, with a specific type of transmission in each of the sectors.

The lower portion of the band up to around 127MHz contains mainly Approach and Tower frequencies, from 129 to 132MHz many airline

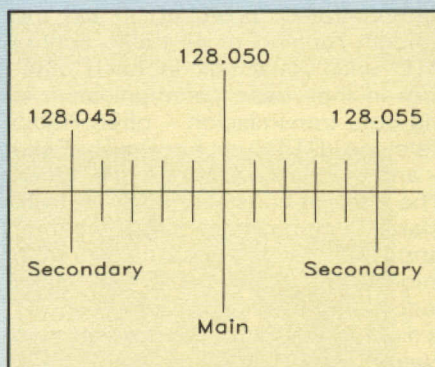


Figure 4. Whilst the two secondary transmissions are $\pm 5\text{kHz}$ from the centre frequency, airband receivers are sufficiently wide band to hear these offset transmitters without the need to retune.

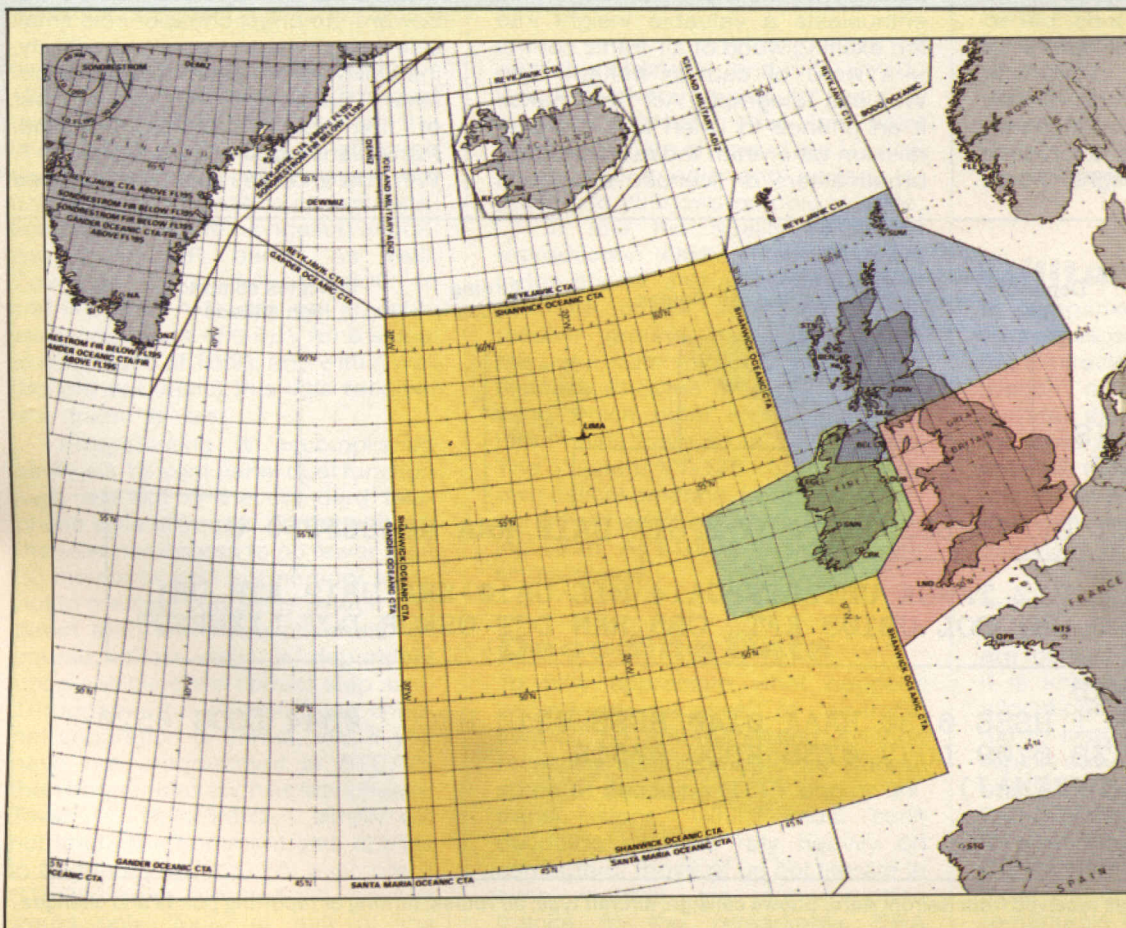
companies have their own channels, whilst the remainder is given over to airways control. Figure 5 shows an example of how such bandspace may be allocated. However, some broadcasts do not fit into these categories. A prime example is the Automated Terminal Information Service (ATIS), this gives pilots runway, weather, barometric pressure and other data. The transmissions can be found on many spot frequencies.

In addition the London Volmet service – providing actual weather at UK and some continental airports – transmits in this band, and with suitable equipment can be heard over much of the country on 135-375, 126-600 and 128-600MHz.

Oceanic Control

As discovered last month, the United Kingdom is responsible for an area of the North Atlantic which stretches westwards between latitudes 45° North and 61° North to Longitude 30° West, this area is highlighted in the map shown below.

Despite advances in satellite communications technology, HF radio still offers the only feasible means of maintaining contact over this vast area, and this is the third tier of the UK air-traffic control system. Aided by computerised data displays



The map shows the oceanic area for which the United Kingdom is responsible.

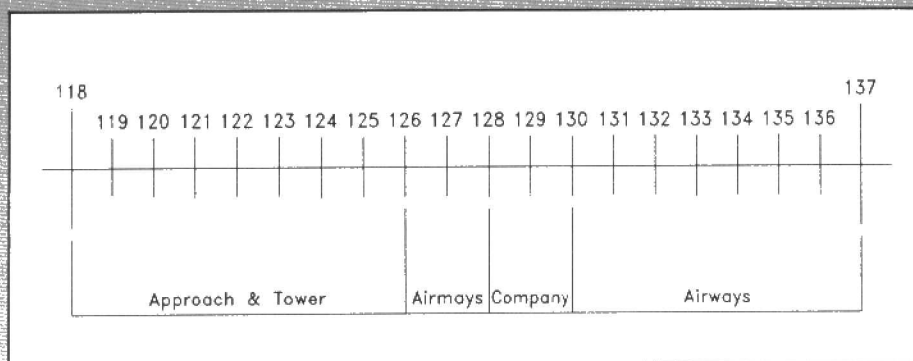


Figure 5. VHF aeronautical bandplan. It should be stressed that this is for guidance only.

with on-line data interchange to other ATC centres, and conflict detection and resolution advice for controllers, the Oceanic Air Traffic Control Centre (OATCC) at Prestwick maintains a round-the-clock watch on all air movements via an HF transmit/receive station at Shannon in the Irish Republic.

Air-traffic control at HF is restricted to spot frequencies from 2 to 23MHz. Again the mode of operation is Simplex but all transmissions are single sideband. This method of transmission has distinct advantages in the crowded HF bands, not least of which is that SSB signals are less affected by ionospheric disturbances, and the bandwidth required to transmit them is very small.

HF Allocation

At first glance allocation of frequencies at HF may seem somewhat haphazard, but here too there is an element of logic. For example, Prestwick OATCC – known as Shanwick Oceanic – utilise frequencies in the 2, 3, 5, 8 and 13MHz bands, but so do the adjacent control areas of Gander, Iceland, New York and Santa Maria. Hence all North Atlantic air-traffic control is grouped together. For those with suitable shortwave receivers, during daylight hours

these stations can be best heard from 8-800 to 8-950MHz, but at night much of this radio traffic moves to 5-500 to 5-680MHz.

ATC to ATC

The fact that aircraft must communicate with ground has been amply demonstrated, however, to aid the smooth running of air-traffic control ATC units must talk to each other too. In their case communication is via data transmission – often Radio Teletype (RTTY) or Facsimile (Fax.) – and much of it is sent by HF radio. The content consists mainly of flight plans, flight progress strips, weather and NOTice to AirMen (NOTAM) information. Some of it can make fascinating reading, Figure 6 shows a flight routing strip as received from Nairobi Aero.

Monitoring

Eavesdropping on communication between air and ground is not only a fascinating hobby, but can give enthusiasts a valuable insight into the exciting world of air-traffic control – a word of caution though. The Wireless Telegraphy Act 1949 makes it an offence to listen to any transmission other than those from public broadcasters or licensed amateurs.

That is the strict letter of the law, but nowadays the authorities take a far more enlightened view of such activities. According to the Department of Trade and Industry's Radio Regulatory Division, "Whilst enthusiasts are not causing nuisance or interference this offence is low on the list of priorities" – in other words they are turning a blind eye!

Hardware

Back in the sixties when aviation monitoring was in its infancy, enthusiasts were hard pressed to find suitable receiving equipment. Now the tables have turned, and there is a bewildering selection of all-singing all-dancing black boxes on the market. What to buy is very much a matter for personal choice, but it boils down to three factors; monitoring needs, operating conditions and depth of pocket. If aviation matters are secondary to other interests such as amateur, marine or satellite communication, then the obvious choice is a 'scanner'. Most offer airband coverage but there is a drawback. Because they are optimised for reception of the FM transmissions prevalent throughout the VHF and UHF bands, resolution of AM signals is very often comprised.

This manifests itself as a lack of sensitivity on the aviation bands, and if you are looking to get the best out of your receiving station it is wise to choose one of the dedicated airband receivers. These fall into two categories – hand-held and base-station. For mobile use a pocket-sized receiver is the obvious choice but beware, amongst cheaper sets small size can mean poor sensitivity, instability and a host of other problems. That said, there are a number of first rate hand-helds around. Particularly good are the Sony Air 7, Win 108 and the recently introduced

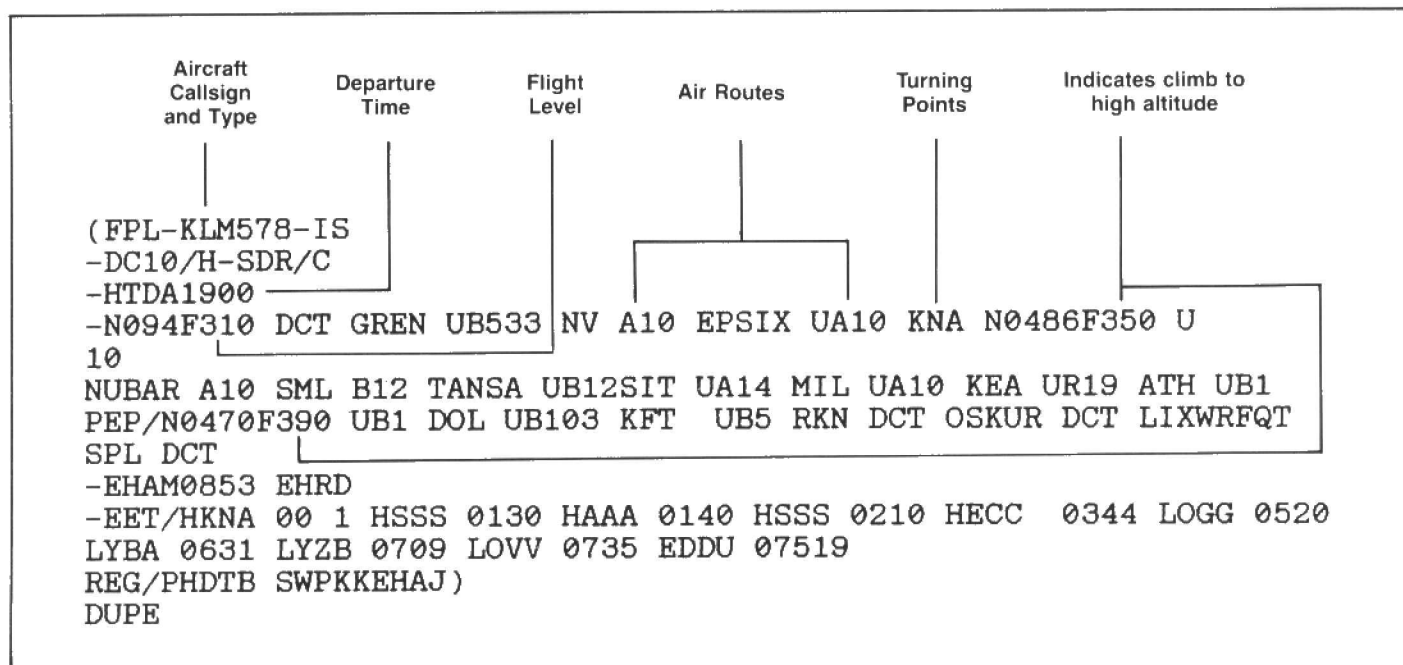


Figure 6. Flight routing strip as received from Nairobi Aero. Shows callsign, aircraft type, air routes, turning or reporting points and changes in altitude.

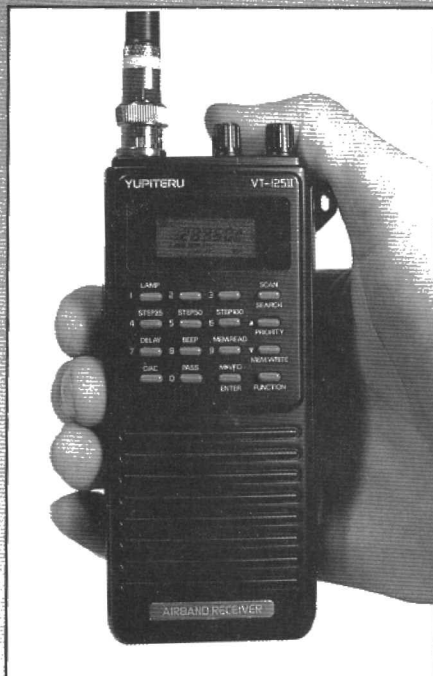
ultra-small Yupiteru VT-125, which is available from Maplin (CM01B).

On the base-station front choice is a little more limited, and the need for ancillary equipment such as outdoor antennas can push the cost up. However, with the constraints of space removed base-station receivers such as the Signal R535 offer significant improvements, and with sets such as the Sony ICF 2001D you will get HF airband coverage as well! It has to be said that airband monitoring is not a cheap hobby, however, quality hand-helds can be had from just a whisker under £170, whilst base-stations start at around £225.

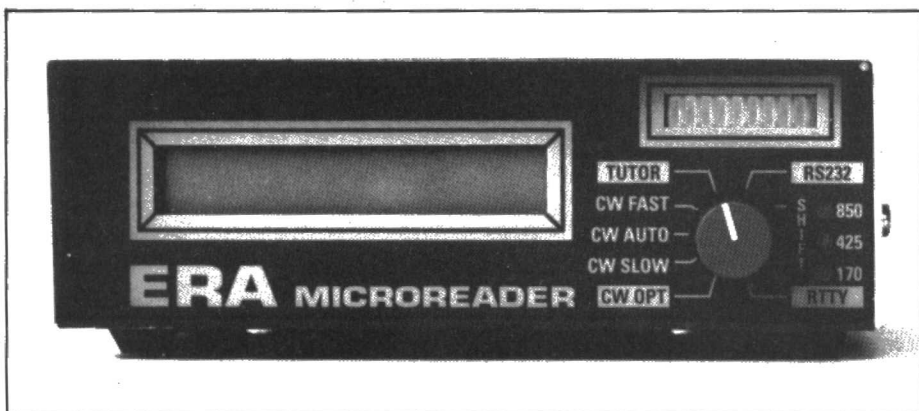
For a range of suitable equipment, take a look in the 'Communications' section of the 1992 Maplin Catalogue.

One of the Best

When the Yupiteru VT-125 was introduced to the market, it was hailed as an airband receiver set to take the world of aviation monitoring



Yupiteru VT-125 hand-held airband receiver.



The ERA Microreader CW and RTTY decoder.

by storm. Measuring in at just 57.2 x 127.5 x 35.5mm this ultra compact hand-held makes full use of the latest SMD technology to offer the user remarkable performance not only across the aviation communications band, but the navigation allocation and PMR bands as well. Coverage is a full 108.000 to 142.000MHz AM with an enviable sensitivity figure of 0.5µV for a signal to noise ratio of 10dB, and with a well thought out layout this little receiver is a dream to use.

Programming is accomplished easily via 16 front panel dual function keys laid out in the standard telephone style of format. Through these the user has access to no fewer than 30 memories with full memory scan, not to mention frequency search and direct entry of known channels. Of course, direct entry is dependent upon selecting the correct step size. Throughout the aviation band channel separation is 25kHz, and if you have not programmed in STEP25 then frequencies such as Manchester Tower - 118.625MHz - simply will not load. The comment also applies to frequency search. For example, if STEP50 were selected the receiver would only 'look' at half of the

available channels, and in STEP100 that is further reduced to just one quarter! However, once this point has been taken on-board the VT-125 is easy to handle and perfect for outings to airshows or local airports.

In use the quality of sound reproduction leaves many receivers in the shade, and as a comparative example of its sensitivity it will resolve ground movement transmissions from my local airport at a distance of some 35 miles - something which other more expensive hand-helds have so far failed to do! The Yupiteru VT-125 comes with its own helical antenna, batteries, external power cord, earpiece and carrying strap. At £169 it is worth every single penny.

Decoding Data

To fully appreciate what happens behind the scenes of air-traffic control, no self-respecting aviation receiving station should be without some of decoding RTTY and/or fax transmissions. Whilst most such decoding systems rely heavily on computers, those of us not literate in such matters are not forgotten thanks to the remarkable ERA

Microreader, which is available from Maplin (XP81C). Connected to the audio output of any suitable short-wave SSB receiver, this device can resolve normal or reversed 45, 50, 75 and 100 baud RTTY with shifts from 170 to 850Hz, and display the results on its own in-built screen. In use the Microreader is a miracle of simplicity. With just one control to select the systems functions, all the user need do is choose the desired baud rate and the unit will do the rest! The Microreader costs £169.

Of course, receiver tuning must be accurate for high quality text, and to aid the user a ten element three colour bargraph LED indicator is provided. In operation, one simply sets the tuning so the two centre red LEDs light, and clear text will appear on the screen. Via the in-built RS232 serial interface, the Microreader can output decoded data to external computers or the newly introduced large screen Microreader display (CM60Q) which costs £185. This add-on device has the advantage of being able to store received text in an 8K RAM/8K ROM memory bank to be viewed at leisure, and can download data to a printer for hard-copy. This versatile system will bring the world of aviation data to life, and to get you started, listed below are a selection of the more fascinating aviation RTTY stations.

RTTY Stations

| Callsign | Frequency | Baud Rate/Shift |
|-------------------|-----------|-----------------|
| Nairobi Aero | 8.165MHz | 50/170 |
| Santa Maria Air | 14.497MHz | 50/425 |
| Kinshasa Air | 18.364MHz | 50/425 |
| Tripoli Air | 19.823MHz | 50/425 |
| Dakar Aero | 19.747MHz | 50/425 |
| Cairo Air | 10.633MHz | 50/170 |
| Dar es Salaam Air | 11.175MHz | 50/425 |

Military Matters

In comparison to civil aviation RT, messages passed by military aircraft are a miracle of brevity. That said, this branch of airband monitoring is perhaps the most fascinating. Within the band 220.00 to 399.990MHz it is possible to listen in on in-flight refuelling, air-sea rescue operations, chit-chat between fighter pilots, low flying exercises and a whole lot more.

The frequencies used are all 'within the public domain' but beware of published listings. Whilst most are correct at the time of printing, it is known that NATO do change allocations frequently as a simple aid to security, hence they become rapidly out-of-date. Perhaps the most entertaining channel to listen to is 243.450MHz - used by the Red Arrows for air communication during displays. Considering the pressure these pilots must be under, conversations are remarkable for their calmness.

KNOWLEDGE-BASED SYSTEMS, NEURAL NETWORKS AND EXPERT SYSTEMS

by Frank Booty

Artificial Intelligence is something they do in universities." This quote says it all. The problem with expert systems and AI to date has been that they are considered to be in a world of their own, and have nothing to do with the 'real' world of data processing. But this attitude is now expected to change.

'Knowledge-Based Systems' (or KBSs) and expert systems belong to the discipline of artificial intelligence (AI). Until recently, the dominant paradigm in the field of AI was that of KBSs. This paradigm, based on the 'Information Processing Theory of Mind' publication in 1972 by Newell and Simon, assumes that intelligence is the capacity of a system to solve problems by means of acquiring, storing, processing, distributing, retrieving and applying knowledge.

Simon has estimated that human experts hold, in their long-term memories, about 50,000 chunks of information relevant to their domain of expertise, probably in the form of 'cue-action pairs', otherwise known as 'productions'. Newell and Simon developed the most widely used knowledge representation formalism to produce standardised productions or rules, and many KBSs are designed to manipulate knowledge represented in this manner. Rules are not the only formalism used in KBSs – it is in many cases more convenient to represent knowledge as 'frames', 'semantic nets' or even English sentences or mathematical expressions.

However, short-term memory, where processing of knowledge occurs, has a very small capacity and represents a processing bottle-neck.

The hypothesis is that the human brain solves problems by creating a symbolic representation of the problem, the so-called 'problem space', and then conducting a search for a solution through the problem space. The search is guided by 'heuristics' contained in productions stored in the long-term memory. In this manner experts have a large quantity of domain-specific productions, and are thus capable of solving problems much faster than non-experts.

"The above paradigm is considered by some researchers as somewhat restrictive, because it is based on the assumption that intelligent behaviour is problem-solving oriented," says Sheelagh Bodenham of the consultancy Esskay Consultants.

"An alternative view has emerged recently which postulates that intelligence is the capacity of a system to *interact* with its environment without clearly defined goals, to learn from this interaction and, in

an incremental fashion, to both articulate and achieve its goals," says Professor George Rzevski of the Open University.

Neural networks, which are a practical implementation of this paradigm, mimic (albeit crudely) the way in which brain cells operate by forming mutual interconnections in response to input signals. These connections are memorised and recalled when a similar signal is again presented to the network. In this way, a neural network is capable of recognising and recalling patterns.

Hence neural networks are predominantly used for the task of trying to discover patterns or recognise shapes of objects. They are seen as black box solutions, i.e., they produce a result, but the user does not know why he has got the answer.

“An alternative view has emerged recently which postulates that intelligence is the capacity of a system to *interact* with its environment without clearly defined goals, to learn from this interaction and, in an incremental fashion, to both articulate and achieve its goals.”

In order to develop a KBS, it is necessary to acquire the relevant knowledge and to arrange it in such a way that it could be stored in a 'knowledge base'. This activity is called 'knowledge engineering'.

Recently, the software company Cincom launched an application life-cycle system for creating and using development, production and maintenance environments. Within the software is 'XpertRule' from Attar Software of Leigh, Lancashire, which is a knowledge engineering tool for integrating rule based and inference processing within mainstream data processing.

Using complex knowledge acquisition and structuring capabilities, it enables the capturing and testing of decision making logic and rules. Once captured, the rules, and the ability to infer from them, are generated as source code modules in a choice of high level languages.

According to David Isherwood, Attar's

Marketing Director, the product was first used for producing the Japanese telephone network. Funding by the EEC and DTI has enabled the product to be marketed in Europe. Among applications built using 'XpertRule' are network system help desks, TV camera fault diagnosis, process control, oil and mineral exploration, switchboard estimation and control, equipment fault-finding and analysis of electronic test data.

The first KBSs appeared in the '70s, and as they contained high level domain specific knowledge elicited from human experts, they were called 'expert systems', some early examples of which were: 'XCON' (formerly known as 'R1'), a system that configures DEC VAX mainframe computers; 'DENDRAL', a system capable of inferring the molecular structure of unknown compounds from mass spectral and nuclear magnetic resonance data; and 'PROSPECTOR', a system that interprets geological data and assesses the likelihood of finding various types of mineral deposits.

All of the early KBSs were American, large and usually written in 'LISP'. The UK – always very strong in AI – tended to develop KBSs which were smaller and written in 'PROLOG'. The key feature of all KBSs is that they are capable of storing the essential knowledge on how to carry out a specific activity.

The consultancy Logica develops or works with both KBSs and neural networks. Indeed, Logica is part of the central team of the LINNET neural network technology transfer club, which was established in 1990, with DTI support "to create wider understanding of the benefits of neural networks and to support newcomers in exploiting the potential of this emerging technology." Other members of the founding team were SD-Scicon and University College, London.

Active research is underway into neural networks within a number of disciplines, including computer science, electrical engineering, physics, physiology and mathematics. Simultaneously, neural nets are being applied to tasks such as detecting credit card fraud and controlling blast-furnaces.

According to Logica, the production of application demonstrator programs provides a mechanism for showing how neural network applications can be implemented. Based at UCL, this work assists the discussion of such practicalities as the choice of training data, basic models, specification of network parameters and comparison with other techniques.

Most current neural networks are based on one of a handful of models, each

of which can be applied to a range of applications, says Logica. This makes the demonstrators selected for LINNET relevant to a variety of organisations – e.g., a classifier of medical symptoms uses the same approach as one evaluating credit risk.

For Logica, current projects in neural networks include applications in defence, and research into network design and control of non-linear systems. At SD-Scicon, work is underway in vision processing, signal reconstruction, target recognition, signal forecasting and video image processing.

Professor Rzevski and Bodenham together set up an AI 'club' at Kingston Polytechnic with £20,000 a year sponsorship from the computer manufacturer ICL. The aims are to identify areas where AI and KBSs could be used both for strategic impact on companies and to add value. Many 'High Street Names' are members.

ICL itself markets its 'DecisionPower' product, which employs an AI technique known as constraint handling to reduce the need to search for alternative solutions to problems. Typical applications include railway timetabling and aircraft flight scheduling.

"Some 30% of applications systems development will be using knowledge based techniques and tools by 1995," says Paul England, IBM's KBS Product Manager. "KBS is really an application development tool, and one we want to get our arms round."

IBM's second generation of KBSs includes 'TIRS' (The Integrated Reasoning Shell), which was first formally made available in September, 1990. However, before this two tests were made at Swiss Air and British Airways respectively. British Airways has one 'live' mainframe application and others under development.

Swiss Air needed to utilise the tarmac it had available at Zurich Airport in the most optimal way. A worldwide network continually passes information related to aircraft flying. In the example of a Swiss Air aeroplane flying from New York to Zurich, a message is passed into Swiss Air's database about the number of passengers, freight, expected arrival time, etc.

At midnight, details about everything that is expected to arrive at the airport are downloaded from the database into a PS/2 network. This enables the airport to establish how it is going to use all its stands for the following 24-hours. Factors such as lateness, technical problems, diversions, etc, can be fed in.

The identification of the aeroplane, its ETA, the number of passengers carried etc., are picked off the main database. Each aeroplane is monitored on a four hour out and two hour out schedule. Some 15 minutes before landing, the airport likes to know which stand to allocate to the aeroplane on arrival. For the New York flight, for example, it may need to be somewhere central and not in a far corner, which ensures easy passenger dispersal.

"It's a true co-operative processing application," says England. "The skills required are not just the KBS. The in-built knowledge is less than 30%. What was also

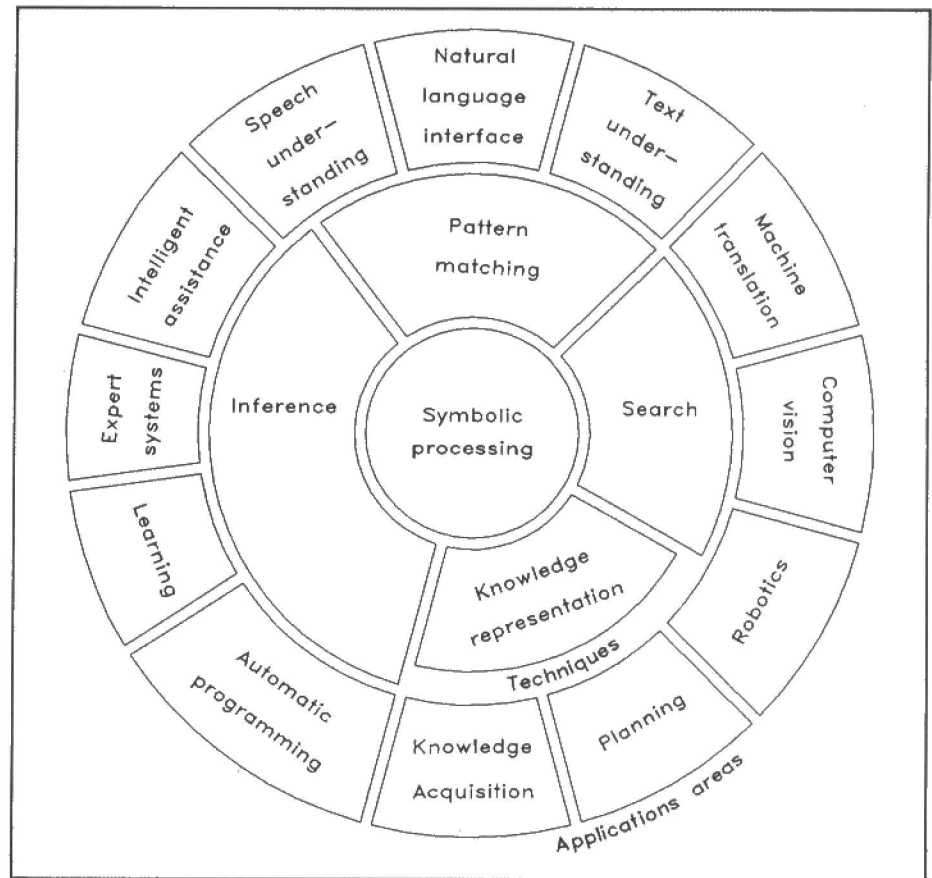


Figure 1. Elements of Artificial Intelligence.

required was a person knowledgeable about airport communications and also OS/2 and C." The project was a joint development between IBM and Swiss Air.

"There is a much greater acceptance of KBS within systems development now, and major customers are beginning to realise this. In the future there will be integration of KBSs and neural networks. Banks and insurance companies are looking at neural nets in terms of the masses of data they can hold."

But, as recently as early 1989, England considers there was no viable, achievable means of embedding a KBS into a communications network. Examples he quotes of KBS applications in such an environment are help desks, AI automated operations and interfaces.

Both Bodenham and Rzevski believe that while the use of stand-alone KBSs will accelerate, more adventurous users will begin experimenting with the application of neural networks. Some organisations will realise that AI could be used as a strategic device, enabling the business to achieve significant objectives. "Wise IT (Information Technology) directors will soon begin to plan the integration of AI systems into networks of distributed information systems," they agreed.

However, many users will continue to employ senior IT management without a vision, and they will by default carry out a piecemeal development of independent KBSs in parallel with maintaining their out-of-date centralised information system architectures. "This will reduce the effectiveness of IT functions and will cause further disillusion with advanced IT."

"A number of vendors will realise that supplying shells cannot provide a reasonable income, and will switch to developing generic KBSs for key business

functions. Many shell vendors who do not detect this message quickly will disappear from the scene."

EXPERT SYSTEMS

Expert systems come from the world of AI (Figure 1). Developed as a result of research into how the human brain works, expert systems bring the powerful commodity of computer-based knowledge to the business world. In the exercise of human reasoning (Figure 2b), people use knowledge and experience (i.e. rules of thumb, ideas, unproven theories, etc.), information and data.

Decisions are reached or conclusions inferred as a result of logical thought (reasoning) processes. Human expertise (knowledge and experience) was a difficult area to computerise, since many of the experts' decisions are relatively unstructured. They are influenced by complex facts and symptoms, and thus are not amenable to the sort of algorithmic programming typical of traditional computing (Figure 2a). Until today, computers have improved efficiency by storing and manipulating data or information faster and more accurately than people.

But expert systems take computers one step further. They are programs that simulate the reasoning processes and the use of knowledge by human experts when solving a problem. One important aspect of expert systems is the use of inferencing techniques to manipulate the expertise required toward solving a problem.

The inference engine is a program that contains generalised strategies used to solve problems, to acquire knowledge and to interface with other systems. It is independent of the application and should

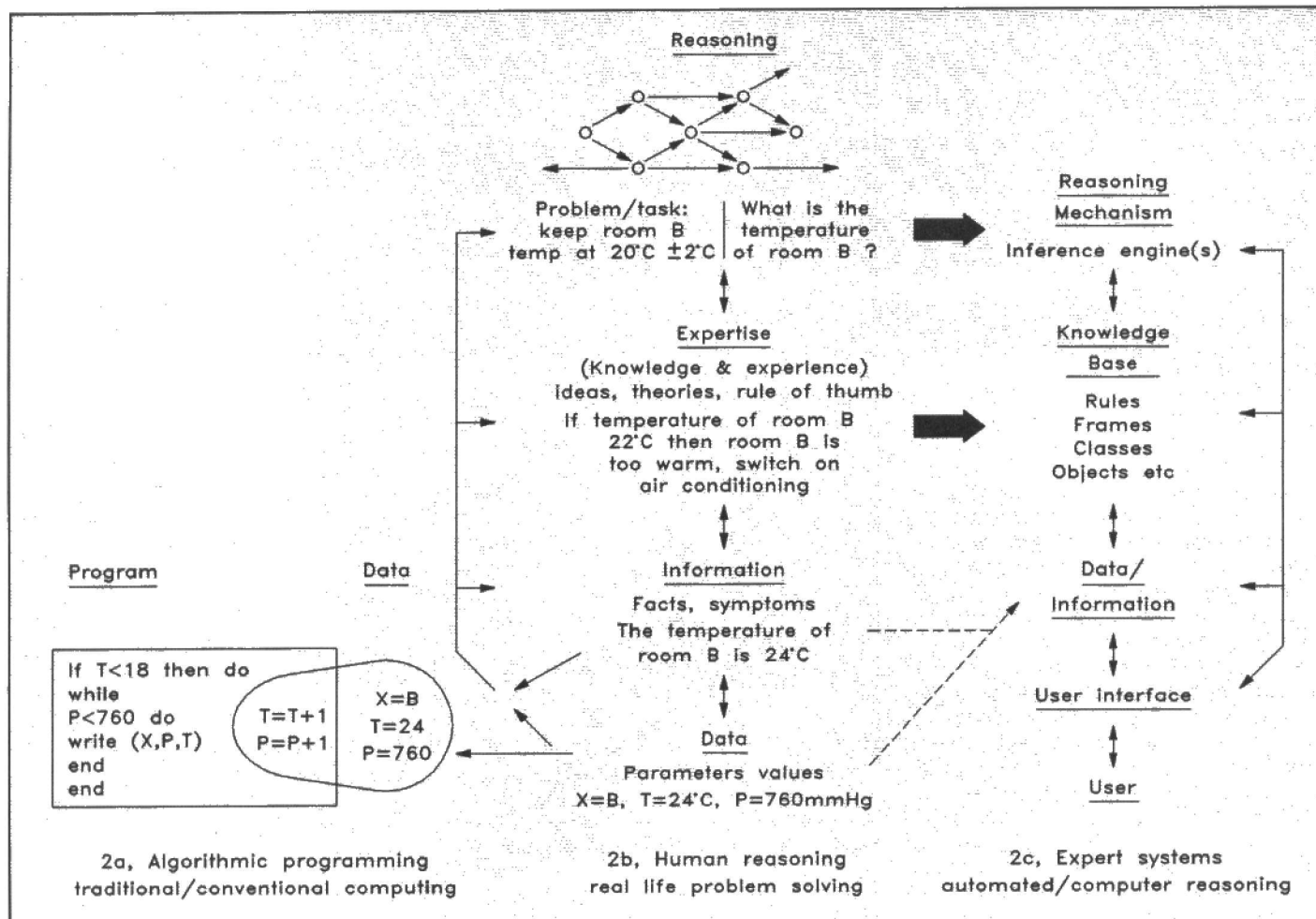


Figure 2. Programming, reasoning and expert systems compared: (a) conventional algorithmic programming; (b) human reasoning; (c) automated expert computer reasoning system.

facilitate explanations, i.e. explain why, justify etc., for the reasoning process. Each combination of the inference engine with a particular knowledge base becomes a unique expert system.

"If a knowledge-based system (KBS) does not combine with an inference engine, then it cannot be considered an expert system because it will not be capable of achieving the full range of reasoning strategies," says Tony Docker of Advanced Expert Systems Ltd of Derby.

"Expert systems handle reasoning and knowledge as well as data and information, a revolutionary step for computers and for the people who use them," says Docker. "They have the power and flexibility to bring the expertise of many human experts to one single person via a simple desktop computer. Expert systems can solve complex problems which previously required the aid of human experts with years of experience. They can produce solutions with the speed, recall, accuracy and consistency that only a computer can provide."

Conventional programs (Figure 2a) embed the knowledge in the instructions, making it difficult for all but a few programmers to understand the logic of the program. Updates to the data are inevitable, but each time the programmer amends the data the chances of introducing unplanned consequences increases. Today's conventional data processing systems are often inflexible, because they cannot be updated efficiently and rapidly.

Nor can they reason in such a way

as to make their contribution relevant to the volatile and stressful conditions of commercial and industrial life. Solving complex problems may require choosing from so many alternatives at each step that it is difficult to algorithmically define solutions. An example of a problem that conventional programming would not be able to tackle cost-effectively is configuring a minicomputer with over three million possible results.

If a non-programmer stopped a conventional program in mid-run and examined the code to determine what was happening, they would not be likely to learn anything at all useful.

Expert systems are different. They represent symbolic processing (not data processing) and are highly interactive. All the knowledge needed to make decisions

is stored in a separate knowledge base (see Figure 2c). The program is thus much easier to understand, and anything in the knowledge base can be changed without a knock-on effect on the reasoning process. A user without any computing experience can halt the processing at any time and ask why a particular line of questioning is being pursued or how a particular conclusion was reached. The expert system will explain and justify its line of reasoning.

Companies in business today should be able to distinguish between what the computer is capable of doing and what functions still have to be done by people using their brains. While the computer can outpace the human brain's rate of calculations by factors in the millions, the machine still seems unable to advance

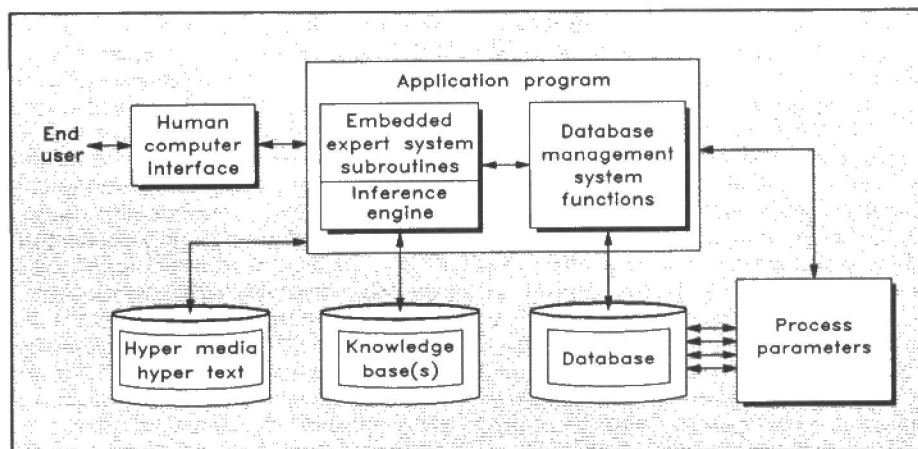


Figure 3. Advanced expert systems architecture.

beyond its number crunching and data manipulation image. Many tasks requiring a high level of human expertise – tasks that cannot be represented in an algorithmic manner – have usually fallen outside the scope of computerisation.

Human expertise is essential to any organisation. The skills obtained from experience are *valuable and difficult to replace* – and they are also hard to share and communicate. Expert systems technology allows the specialists to transfer their expertise (i.e., knowledge and experience) to a computer system. Further, it provides the means to disseminate expertise in a comprehensive and cost-effective manner. Such technology is proving particularly useful in those areas of an organisation where the availability of expertise is crucial to the job, and its successful application can give the organisation a competitive edge.

The benefits of expertise can be even further extended by integrating expert systems with existing data processing oriented computer systems, for example databases, management systems, process monitoring, hypermedia, etc. (see Figure 3). The integration of expert systems technology with existing real world applications will boost the efficiency and productivity of these applications and the quality of their solutions. It will allow the development of more advanced intelligent systems which would not have been cost effective using conventional computing techniques.

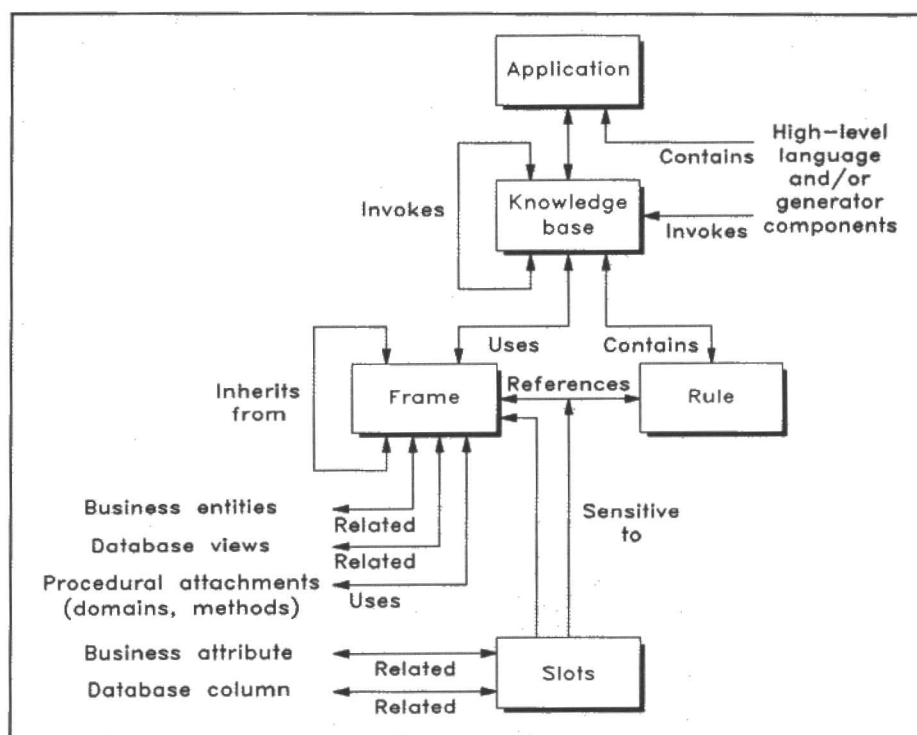


Figure 4. Hypothetical model of a knowledge-based application.

Expert systems can be used to control processes, monitor equipment, diagnose problems and faults, explore options, configure systems, give advice, plan and schedule activities, etc. All this can be done at the experts' skill level and the non-specialist's level of understanding.

Expert systems *do not* replace human experts. Instead they can free the experts

from the 'nuisance' role of the consultant, and help them to focus on the more productive areas of their specialities, while non-experts will be more productive and able to make more accurate decisions. How such an expert system application might be structured is outlined in Figure 4.

In next month's issue Frank Booty takes a look at virtual reality.

MAPLIN'S TOP TWENTY KITS

| POSITION | | DESCRIPTION OF KIT | ORDER AS | PRICE | DETAILS IN |
|----------|------|-------------------------------|----------|--------|------------------------|
| 1. | (1) | LED Xmas Star | LP54J | £ 6.25 | Magazine 48 (XA48C) |
| 2. | (3) | Live Wire Detector | LK63T | £ 4.25 | Magazine 48 (XA48C) |
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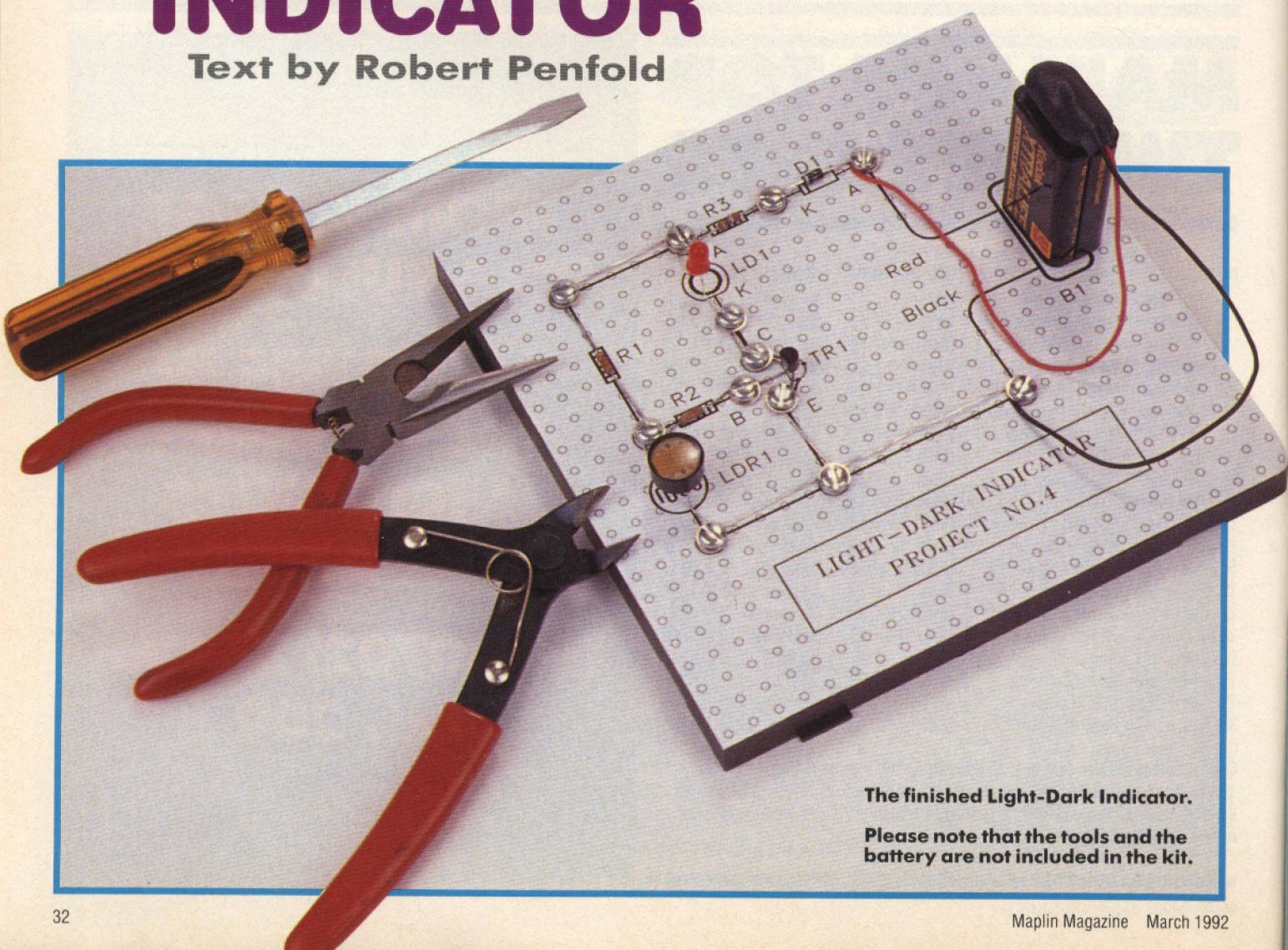
LIGHT-DARK INDICATOR

Text by Robert Penfold

This is the fourth in a series of easy-to-build electronic projects for complete beginners, who require a simple and fun starter to electronic project building. These projects are ideal for the young person as no soldering is needed. All the projects are built on the same type and size of plastic 'peg-board'. The only tools needed to build this project, and the others in the series, are a pair of wire cutters/strippers and a small screwdriver; a pair of pliers would also be useful.

This Month's Project

Light-operated switches are much used in day-to-day life, such as in street light switches, lift-door protectors, and other similar uses. This project is a very simple light-operated switch. In fact, it simply switches on a light-emitting diode (LED for short) indicator if it detects the absence of light. With a simple change to the circuit, this project will do the opposite — in other words, it will operate the LED indicator if the light level is above a certain amount.



The finished Light-Dark Indicator.

Please note that the tools and the battery are not included in the kit.

How it Works

The circuit diagram for the light-operated switch is shown in Figure 1. This is the darkness detector version of the unit (The 'lightness' detector is dealt with later). At the heart of the circuit is LDR1, the 'photocell'. This component is known as a 'light dependent resistor' (LDR for short), which means simply that its electrical resistance changes in sympathy with the light level that it receives. In darkness, LDR1 has a very high resistance, but in strong light it conducts electricity quite well.

Let us look, first of all, at how the circuit behaves in darkness. In this case, LDR1 has such a high resistance that it has very little effect on the circuit. The current through resistors R1 and R2 is enough to switch on the transistor (TR1), which in turn switches on the LED (LD1). R3 reduces the current flow to a level that is safe for both TR1 and LD1. D1 is a protection diode which is included in all 'Funtronics' projects. All this does is to 'block' the supply, should you accidentally connect the battery around the wrong way. This is because D1 (and all other types of diode, for that matter) allows electricity to flow in one direction only.

If the room is lit, or the unit is placed in daylight, the light level received by LDR1 is quite high. Because its resistance decreases, this component 'taps off' most of the current that would flow into the 'base' of TR1 if no light were to fall on LDR1. As a result, not enough current is present at this point to switch TR1 on, and so LD1 remains turned off. The circuit does not provide a true 'switching' (in other words, on/off) action; in other words, LD1 will light up dimly, over a small range of 'in-between' light levels.

Getting it Together

Firstly, read through this section and then *carefully* follow the instructions, one step at a time. Refer to the photographs of the finished project if this helps.

1. Cut out the component guide-sheet provided with the kit (which is a full-size copy of Figure 2), and glue it to the top of the plastic board. Paper glue or gum should be okay. Do not soak the paper with glue, a few small 'dabs' will do.

2. Fit the link-wires to the board using the self-tapping screws and washers provided. The link-wires are made from bare wire. Loop the wire, in a *clockwise* direction around each screw to which it must connect, taking the wire under the washers. Do not fully tighten a screw until all the leads that are

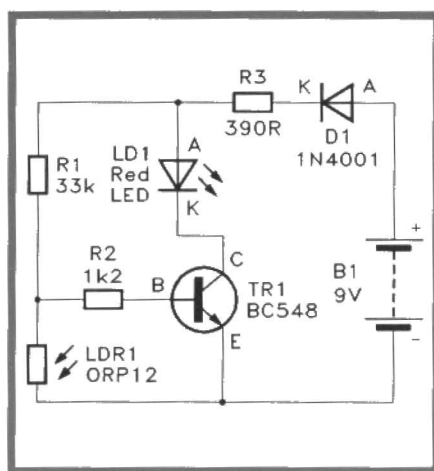


Figure 1. The Light-Dark Indicator Circuit Diagram. LDR1 is the photocell.

under it are in place, and do not over-tighten the screws, otherwise the plastic board may be damaged.

3. Recognise and fit the components, in the order given below, using the same method as for the link wires. Cut the components' wires so that they are just long enough to loop around the screws; otherwise long leads left flapping around may touch each other (this is known as a 'short-circuit') and may stop your circuit from working.

a) The first components to be fitted are Resistors R1, R2 and R3. These are small sausage-like components having a lead-out wire at each end, and four coloured bands around their bodies. The fourth band tells us how near to the given value the resistor is likely to be. This fourth band is known as the

'tolerance' band, and is gold in colour. However, we are interested in the first three bands, which tell us the value of the resistor. For R1, these bands are all orange. The colours for R2 are brown, red, and red again. The colour of R3's first three bands are orange, white and brown. These three coloured bands on each resistor tell us that: R1 has a value of 33,000 ohms, which is often written as 33 kilohms (or 33kΩ for short); R2 has a value of 1,200 ohms (written as 1k2 for short); and R3 has a value of 390 ohms (written as 390R for short). Unlike diodes or transistors, it does not matter which way round resistors are connected.

b) Next fit the LED, LD1, which is a 'blob' of clear red plastic, with two wires coming out of one end, as shown in Figure 3. It is fitted in the position shown on the guide-sheet, and *must* be connected the right way round – or it will not light up. One side of the LED is flattened (the lead on this side of the LED is known as the cathode (K), while the lead on the other, rounded, side is called the anode (A)). Make sure that the LEDs are fitted so that the 'flattened' sides line up with the drawing of the LED printed on the guide-sheet.

c) The next component to be fitted is D1, which is a small tube-like component having a lead at each end of its black body, as shown in Figure 4. Like LD1, it must be connected the right way round (In other words, D1 is a 'polarised'

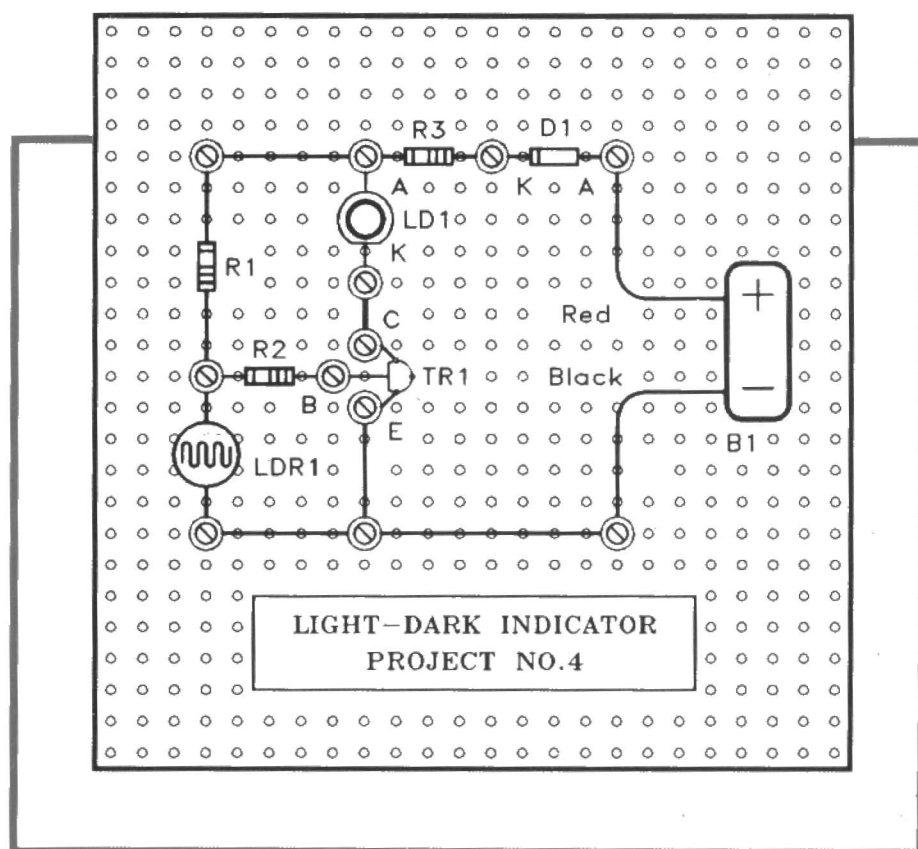


Figure 2. The component guide-sheet for the Light-Dark Indicator.

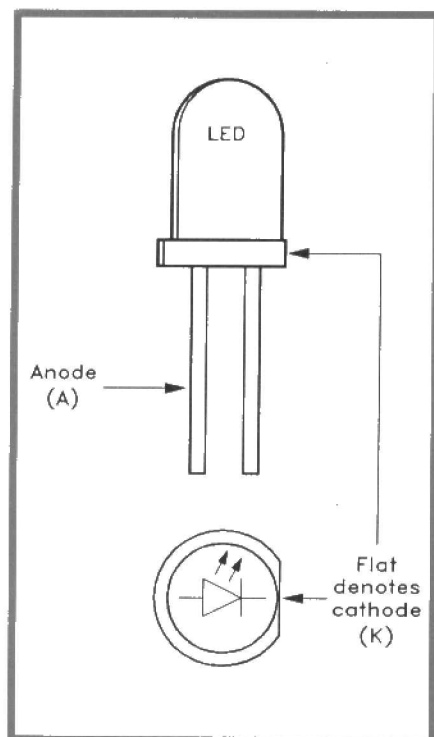


Figure 3. LED (LD1) connections.

component). Its 'polarity', which tells us the way in which it must be positioned, is indicated by a white (or silver) band close to one end of the body. The diode should be fitted so that the band lines up with that on the drawing of the diode on the guide-sheet.

d) TR1, the transistor, should now be fitted to the board. This has a small black plastic body with three lead-out wires. It will be marked with the type number, which in this case is 'BC548'. Other markings may also be present; you will have to get used to picking out the important markings on chips and transistors (and ignoring the others!). You must ensure that TR1 is fitted to the board correctly. Figure 5 shows which lead is which, making this task easy.

e) Next, fit LDR1, which is a thick disc-shaped component having two lead-out wires. The shiny surface with the visible zig-zag 'pattern' is the light sensitive one, and should face upwards. The distinctive pattern is in fact the track of light sensitive material (cadmium sulphide in this case). LDR1, being a resistor, can be connected either way round.

f) Lastly, fit the battery connector and battery, B1. The connector must be attached to the board with its coloured leads the correct way round. The battery connector has two press-stud clips on a piece of plastic and two wires coming from it, coloured red and black. The red and black leads should be connected as shown on the guide sheet. The 9V PP3 type battery should be connected to the battery connector; it will only fit properly one way round.

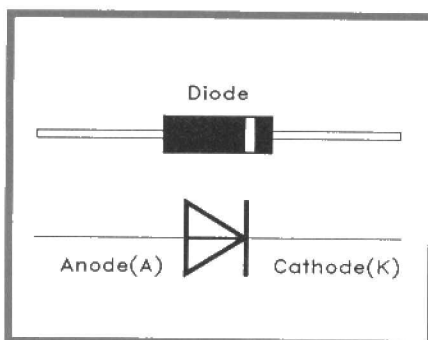
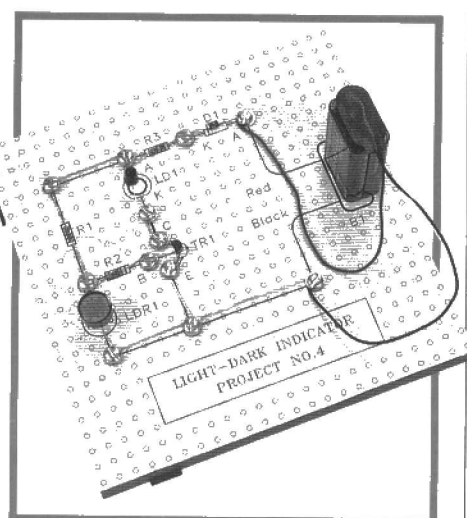


Figure 4. Diode (D1) connections.

Testing and Use

After checking that everything is in the right place and properly connected to the terminals, connect the battery to the battery clip. LD1 should not light up when the assembled unit is placed in daylight. Even the lower light levels produced by most electric lighting should keep LD1 turned off. Therefore, if LD1 switches on, disconnect the battery AT ONCE and recheck the wiring. In particular, make sure that LD1, D1, TR1, and the battery are fitted the right way round.

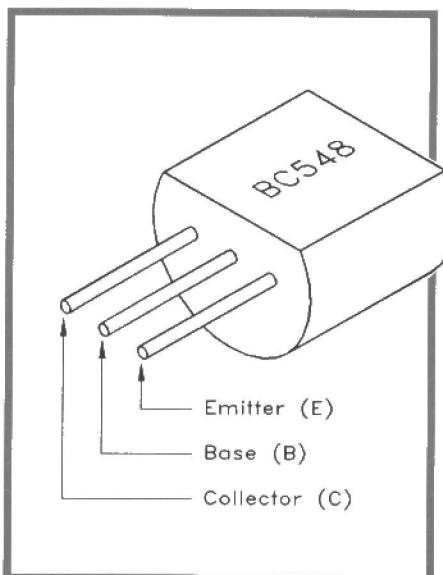


Figure 5. Transistor (TR1) connections.

If LD1 does not switch on, try placing your hand over LDR1, so that it receives very little light. This should force LD1 to come on. Although the circuit does not provide strict on/off switching, you should find it difficult to position your hand so that LD1 glows with anything less than full brightness. The high signal gain of the transistor ensures that only a very narrow range of light levels give 'in-between' brightness from LD1.

Using the Circuit as a Light Detector

In order to get the unit to work as a light detector, simply swap over R1 and LDR1. When LDR1 is subjected to light conditions, TR1 is now provided with an input current. TR1 then switches on, and turns on LD1. When LDR1 is in darkness, very little or no input current is supplied to TR1. Neither TR1 or LD1 are switched on as a result.

Uses of the Light-Dark Indicator

With LDR1 and LD1 within only centimetres of each other, the unit has little practical use. However, if you connect either LDR1 or LD1 to the main unit via a piece of two-way cable (which can be a few metres long if necessary), LDR1 or LD1 can be remotely located from the rest of the unit. A useful purpose for a project of this type is a photographic darkroom indicator. In this case, the unit would be set up as a darkness indicator, with LDR1 mounted inside the darkroom, and LD1 mounted outside it.

If LD1 is switched on, this would indicate that the room was dark. In other words, developing of film could be taking place, and so it may not be safe to enter the room. On the other hand, LD1 being switched off indicates a high light level in the room, telling us that it would be safe to enter (assuming, of course, that the unit's battery had not run down!).

Availability

The Funtronics Light-Dark Indicator is available from Maplin Electronics, through our chain of regional stores, or by mail order, order code LP93B Price £3.95.

Next Month

Have you ever wondered how flashing lights work? Behind a lot of these you will find a circuit called a 'multivibrator'. *Funtronics* in the April issue of 'Electronics' shows you how to build such a 'flasher' circuit.

Design and Application of SEQUENTIAL LOGIC

PART
THREE

by Graham Dixey
C.Eng., M.I.E.E.

In the last issue we looked at the design of asynchronous counters, using a semi-discrete approach in which the design was carried out by wiring up the appropriate combination of flip-flops and gating logic. However, it was mentioned that there are many MSI chips which contain complete counter circuits, thus making unnecessary much of the interconnecting required by the approach described. Where an MSI device that exactly matches one's requirements exists, it makes sense to use it. However, because the number of counter types possible runs into very large numbers, quite a few MSI chips offer a flexible approach in which the full function of the completed circuit can be defined by the way its pins are utilised. For example, some counter ICs require additional logic to be used to obtain a range of functions. Others are the so-called 'programmable' (sometimes

simply called pre-settable) counters which permit the counter length to be determined by initialisation of the counter and its subsequent disabling, both at specific instants of time. The purpose of this article is to look at a few counter ICs that fall into the former category and to see how they may be used to obtain a given count sequence.

Asynchronous MSI Chips

Asynchronous counter chips are definitely in the minority. In the CMOS range there is a good example in the shape of the 4024BE and in the TTL range there are the 7490, 7492 and 7493; there is also an HC version of the CMOS 4024 known as the 74HC4024 which is pin compatible. However, many different

counter circuits can be readily designed around these few chips, with or without some extra logic.

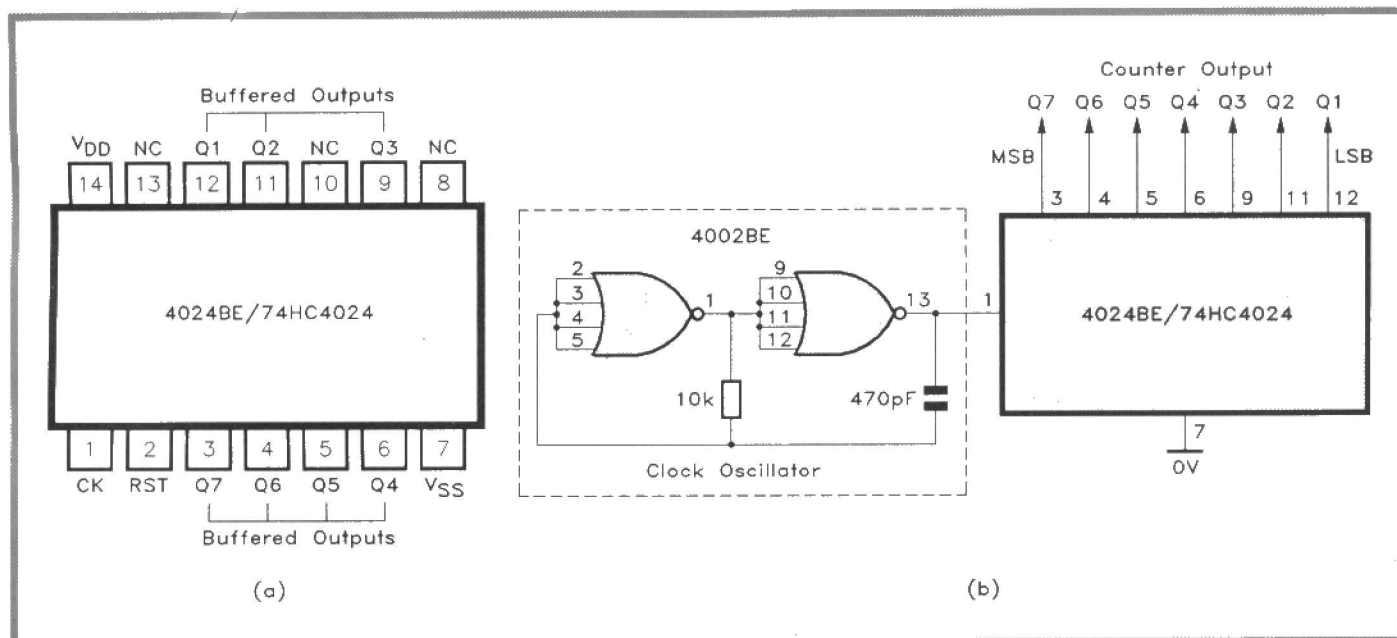
The CMOS 4024BE/74HC4024 Counter IC

The pin-out diagram for this device is shown in Figure 1, together with a block diagram in which it is driven from a simple CMOS oscillator and provides an overall division ratio of 2^7 or 128. Since all of the Q outputs are available separately (not a feature of all counter chips), any intermediate ratio is also available. This is its most basic mode, but it is possible, by means of extra logic, to make it perform any desired sequence.

A Divide-by-60 Asynchronous Counter

Figure 2 shows one particular case for a 'less than maximum' count sequence for the 4024. The counter length of 60 has been chosen as an example. This is a useful sequence because it allows the conversion of seconds into minutes and, similarly, the conversion of minutes into hours. This makes it useful for timing applications, the most obvious of these being the digital clock.

A relatively small amount of extra logic is seen to be needed: two gate packages and a flip-flop package. The principle of the counter is similar to that of the asynchronous counters discussed in the last issue. A reset is forced at the required point in the sequence, thus forcing the counter to skip some of the later states. The main difference is that the 4024 requires a logic 1 level on its RST (reset) pin in order to clear the counter. This particular method works by detecting the N-1 state of the counter, which is the



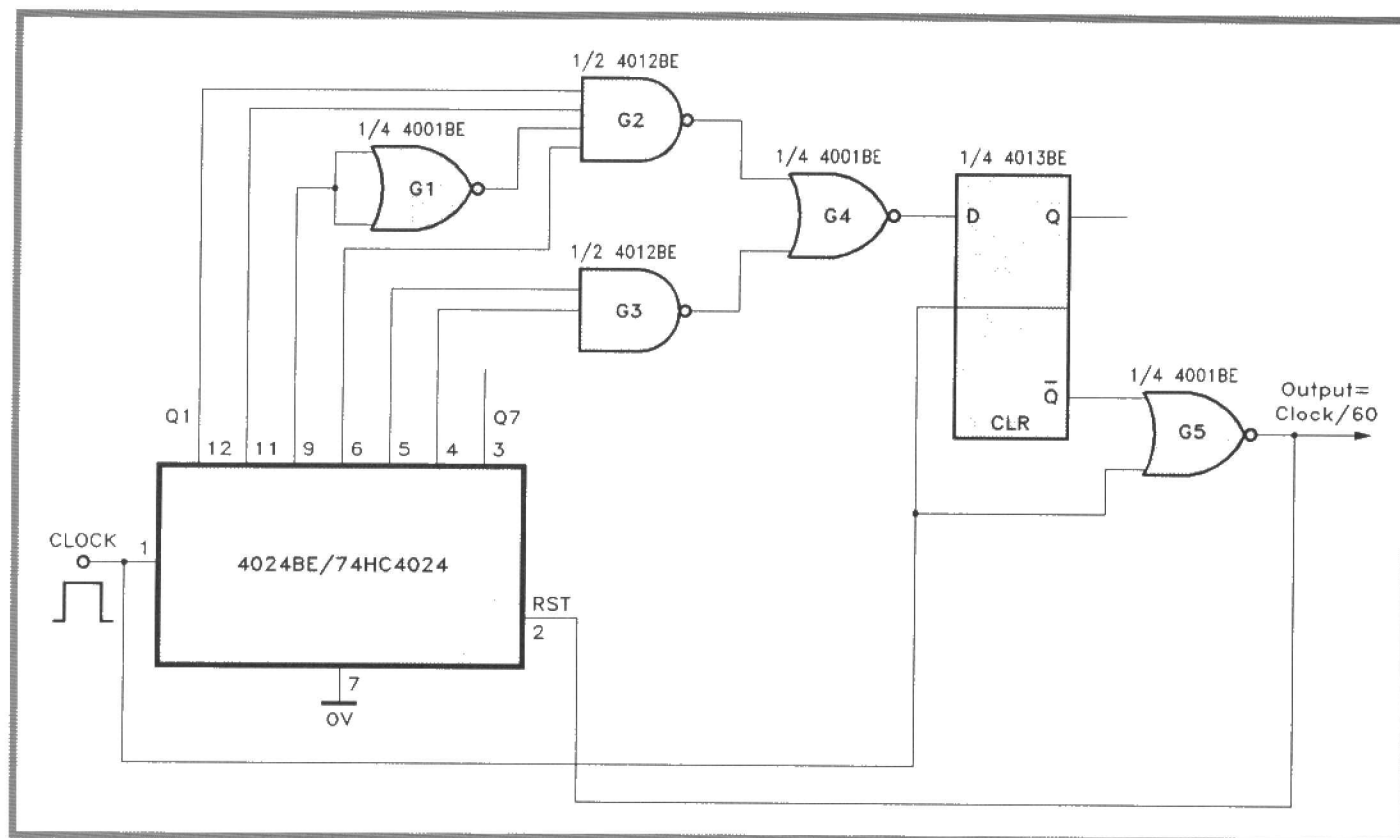


Figure 2. The 4024 with extra logic to force a 'divide-by-60' count sequence.

last required state. If this at first seems wrong, remember that the first state of a counter is 'all zeros'; this is followed by the sequence of numbers from 1 to $N-1$, giving N values altogether. This is in contrast with the method of counter design discussed in the last issue in which the counter was allowed to go, momentarily, into the first 'unwanted' state (hence state N) before the reset level was generated.

The presence of the $N-1$ count is detected by the NAND gating, G2 and G3, and, as a result, a logic 1 level is presented at the data input of the D-type flip-flop. To perform this gating the outputs of the 4024 are considered and the following action taken.

- For any logic 1 output from the counter, occurring in the $N-1$ count state, this output is NANDed directly.
- For any logic 0 in the counter output at this time, this level is first inverted before being NANDed.
- If the number of NAND gates used is two or more, their outputs are NORed, and this final output drives the D input of the flip-flop.
- If only one NAND gate is needed (as would be the case for very small values of N), then its output is simply inverted before driving the flip-flop.

In the case of the divide-by-60 counter shown in Figure 2, the binary value of $N-1$ count (denary number 59) is 0111011. This is, of course, in the order, reading from left to right, $Q7 \rightarrow Q1$. Since the count is less than 64, the bit $Q7$ will always be zero and can be ignored. It remains only to gate the outputs $Q6$ down to $Q1$. All of these are logic 1s except for $Q3$, which is logic 0. The latter is the only one needing to be inverted, the others

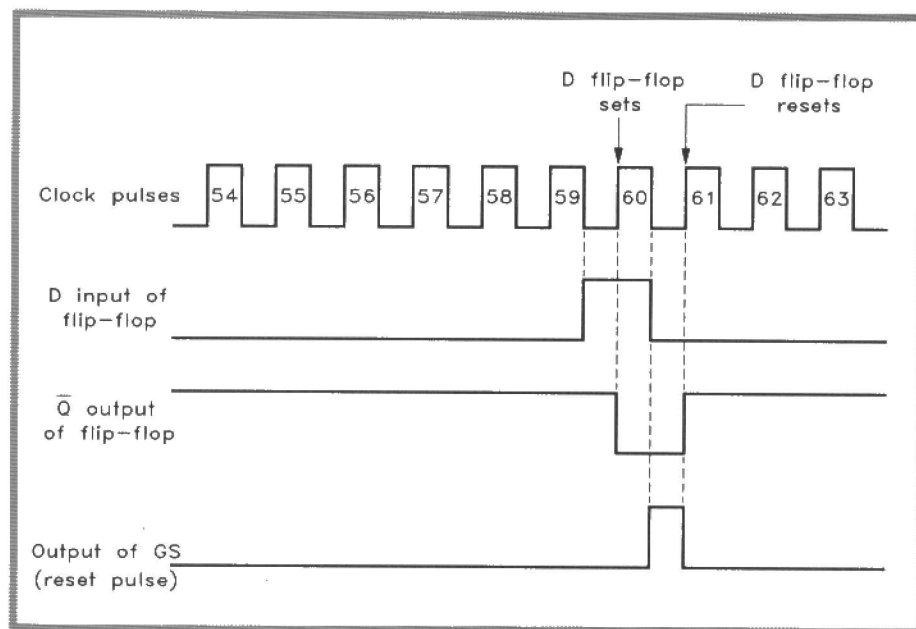


Figure 3. Waveforms for the circuit of Figure 2 at the reset point in the sequence.

being NANDed directly, as the diagram clearly shows.

If the gating has been correctly designed, then the output of gate G4 will be a logic 1 when, and only when, the count 59 has been reached. This will have happened on receipt of the 59th clock pulse input. Thus, we are now waiting for the 60th clock pulse to arrive, when the following sequence will occur.

- On receipt of the leading edge of this 60th pulse, the D flip-flop will set and its \bar{Q} output will go to logic 0. At this instant the two inputs to the NOR gate G5 will be logic 0 (from the \bar{Q} output of the flip-flop) and logic 1 (the clock pulse), respectively; the output of this

gate will, therefore, be logic 0.

- Assume now that the clock pulse finishes and its level goes low. As soon as this happens, the inputs to gate G5 will both be logic 0 and the output of this gate will go to logic 1. This rise constitutes the leading edge of the output pulse. However, this high level is coupled back to the reset (RST) pin of the 4024 and, hence, the latter resets.

As soon as it does so all of its Q outputs go to logic 0, resulting in the output of gate G4 once more becoming logic 0.

- The very next clock pulse will cause the flip-flop to reset, \bar{Q} will return to logic

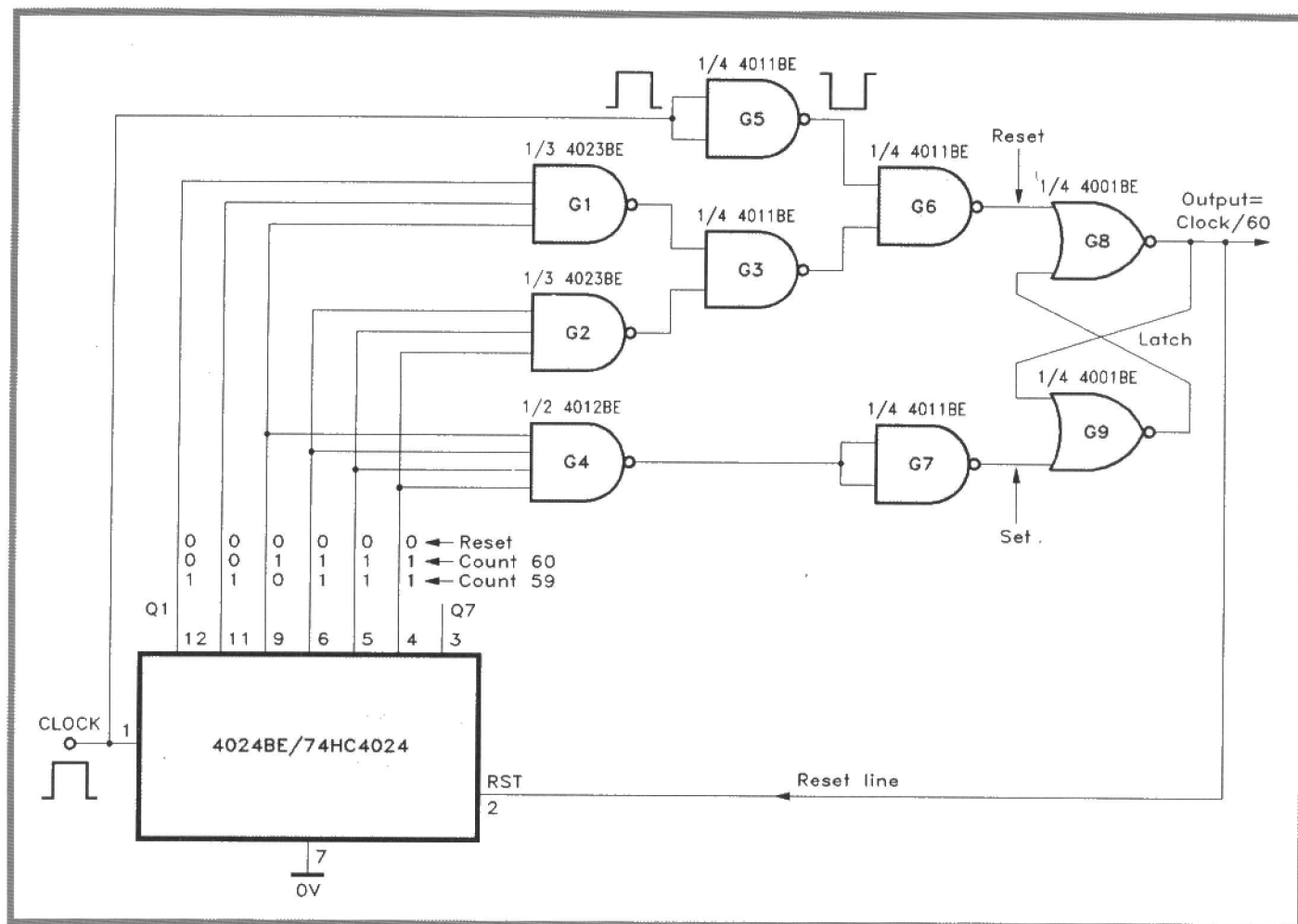


Figure 4. An alternative 4024 circuit for a 'divide-by-60' counter.

1 and the output of gate G5 will return to logic 0. This marks the trailing edge of the output pulse.

It will be noticed that the duration of the pulse output from G5 is quite short, in fact equal to half of the clock pulse cycle time. This is in contrast with the behaviour of many 'divide-by-N' counters, in which the output is a full square-wave at the lower frequency with both mark and space being equal. In counters of the type of Figure 2 the output is always simply a single short pulse occurring at a rate of '(clock frequency)/N' pulses per second. The relevant waveforms at this time are shown in Figure 3.

This design approach illustrated here is based upon the detection of the final output state, this being used to perform the reset. This can now be contrasted with an alternative design in which the first unwanted state, following the highest required state of the counter, is detected in order to perform the reset. A counter designed on these principles is shown in Figure 4.

The output from a NOR latch (gates G8 and G9) provides the RESET (RST) line to the 4024. For any count in the range 0-59 the output from this latch is low, allowing the counting to proceed normally. However, on the counter going into the 'count 60' state, on receipt of the 60th clock pulse, the output of gate G4 goes low since all of its four input lines (Q3-Q6) are now high. This low level is inverted by gate G7 whose output drives

the SET input of the NOR latch. This positive transition at the SET input causes the latch to set, forcing the reset line high and resetting the 4024 counter chip. As soon as this happens, of course, all Q outputs fall to logic 0 and the outputs of NAND gates G1, G2 and G4 all go to logic 1. The change in G4 has no effect since the net result here is that the SET input of the NOR latch merely returns low. However, the outputs of G1 and G2, both being high, cause the output of G3 to go low; this in turn makes the output of gate G6 go high which, being the RESET input of the NOR latch, causing the latter to reset. It remains in this state for the duration of the next counting sequence, as previously stated, when the above operation is then repeated.

To help follow the above explanation, the logic levels at the Q outputs of the 4024 chip, for the 59th, 60th clock pulses and the following reset, have been included on the circuit diagram of Figure 4. For those who have difficulty in memorising or visualising the truth tables for NAND and NOR logic, the following summary may be of some help.

NAND logic: The output from a NAND gate is always logic 1 except in the ONE case when ALL inputs are at logic 1, when the output then becomes logic 0.

NOR logic: The output from a NOR gate is always logic 0 except in the ONE case when ALL inputs are at logic 0, when the output then becomes logic 1.

The TTL Counter ICs 7490, 7492 and 7493

The pin-out diagrams for these three ICs are shown in Figure 5, and possibly the first point that one may notice is that the supply connections are rather unusual. Whereas many TTL chips use pin 14 for the positive supply and pin 7 for the 0V connection, these three chips use pins 5 and 10 for these functions, respectively. Each of the chips has a pair of clock inputs, marked as CLOCK 1 and CLOCK 2. This arises because these three counters each contain a separate divide-by-two element (driven from the CLOCK 1 input) and further 3-stage section that gives a division of FIVE (7490); SIX (7492) and EIGHT (7493). Thus, if the two internal sections of the chips are cascaded we get that:

The 7490 is a modulo-10 counter (or decade counter).

The 7492 is a modulo-12 counter.

The 7493 is a modulo-16 counter.

The logic which controls these particular division ratios is internal to each IC. Presetting a ratio is possible with the 7490, but not for the other ICs.

The 7490 has two '0 set' pins and two '9 set' pins. For normal counting at least one of each of these 'pairs' of pins must be taken to logic 0. If it is required to reset the counter (that is, all Q outputs go to logic 0) at any instant, then both of the '0 set' pins must be taken high together. This provides a normal reset facility but

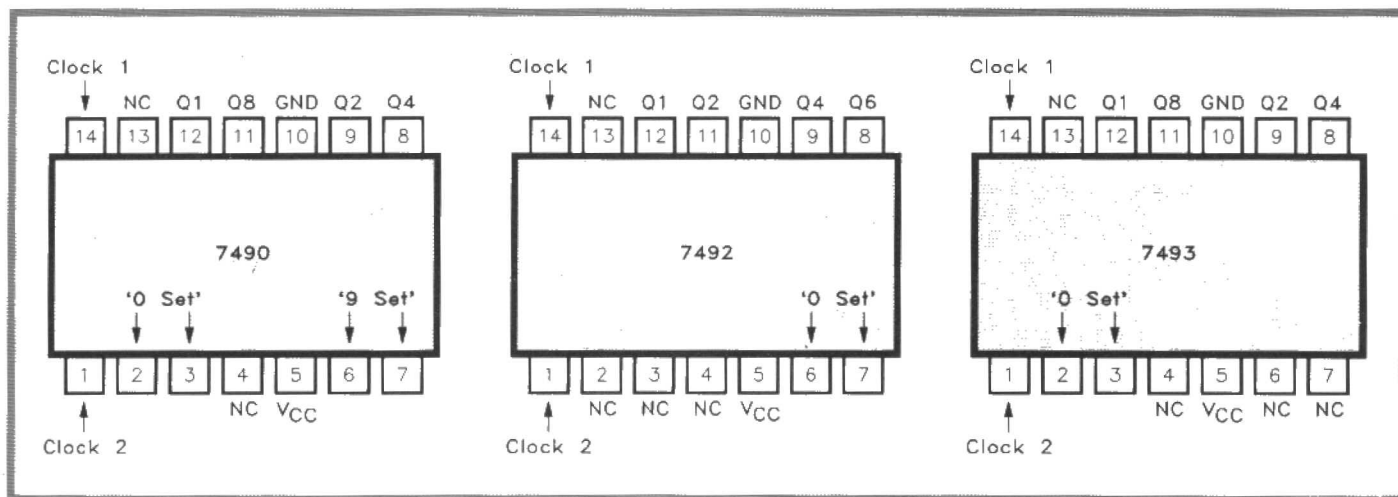


Figure 5. Pin-out diagrams for the 7490, 7492 and 7493 counter ICs.

with the possibility that the logic levels on both '0 set' pins may be controlled separately, so allowing external 'decision making' to decide when a reset shall occur. Of course, if these pins are permanently connected to logic 0, then the counter will count through the normal BCD sequence, 0000 to 1001, before automatically resetting to all zeros.

The two '9 set' pins of the 7490 allow limited presetting to the count 1001 (denary 9) when desired, by controlling their potential in the same manner as described for '0 setting'.

The 7492 and 7493 chips both have a pair of '0 set' pins only, which operate in the manner described above for the 7490.

To use any of these three ICs for their full count sequence, all that is necessary to do is to apply the clock input to pin 14, strap pins 12 and 1 together and take the output from the four Q outputs.

Modifying Count Sequences

It is very easy to modify the length of the count sequences for these three chips, as will now be shown. No external logic is required, merely the appropriate interconnections between the chip pins. The method is based upon the use of the '0 set' inputs and a circuit of this type is shown in Figure 6. This example shows a 7490 counter that has been wired to produce modulo-6 count sequence. The '0 set' inputs are controlled by the levels on pins 8 and 9 of the IC.

Since the maximum count of a modulo-6 counter is 101 (denary 5), only a three bit output is required; the highest weighted bit (Q8) of the 7490 is not utilised. The clock pulses are applied to the clock input of the divide-by-2 element (pin 14) and the output of this section (pin 12-Q1) drives the clock input (pin 1) of the divide-by-5 section. Two feed-back connections are taken from Q2 and Q4 to the '0-set' pins 2 and 3 respectively. The secret to shortening the count sequence from the normal 10 to six lies in driving these two pins to logic 1 at the same time, thus resetting the counter.

Starting with the counter reset, the first five clock pulses produce the binary

sequence: 000, 001, 010, 011, 100 and 101. This is the full scale-of-six sequence. For the counter to work, the next clock pulse must cause a reset. That it will in fact do so is clear when it is seen that the next state is 110. The two 'ones' represent the outputs at pins 9 and 8 respectively; both '0-set' pins are taken high at the same time and the counter resets to the 000 state.

There is an obvious disadvantage with this particular circuit. Both reset pins are tied up in the feed-back arrangement and this leaves no external reset facility available. This can be overcome by gating the outputs on pins 8 and 9 (AND logic) to drive a 'reset line', the latter also capable of being controlled separately through a reset switch. A moment's thought will show that this is likely to suffer from the same hazard that was encountered in similar types of counter discussed in the previous part of this series. Because of differing switching speeds, not all flip-flops will reset at the same time, thus allowing the reset line to go low before all flip-flops have had a chance to reset. The solution is the same as it was then; a latch is used to ensure that the circuit resets properly. The only difference in this particular circuit is

that the alternative output from the latch will have to be used, since a logic 0 is required to reset the counter in this instance. The circuit modified is shown in Figure 7.

The counter circuit of Figure 8 shows the 7490 again, this time connected as a modulo-9 counter. To achieve this, one of the '0-set' pins (pin 2) is connected to Q1, while the other (pin 3) is connected to Q8. The former of these two reset pins will alternate between the logic 0 and logic 1 states at half the clock frequency. The latter reset pin will only go to logic 1 when a count of 1000 (the last wanted state in the sequence) is reached. On the next clock pulse, Q1 goes high, as the counter enters the 1001 state; at this instant both '0-set' pins are at logic 1 together and the counter resets. This counter suffers from the same limitations as the previous one and can be similarly modified.

Straight Count Sequences

The two foregoing examples, illustrated with the 7490 decade counter, show the sort of technique used when a count less than the maximum possible is required.

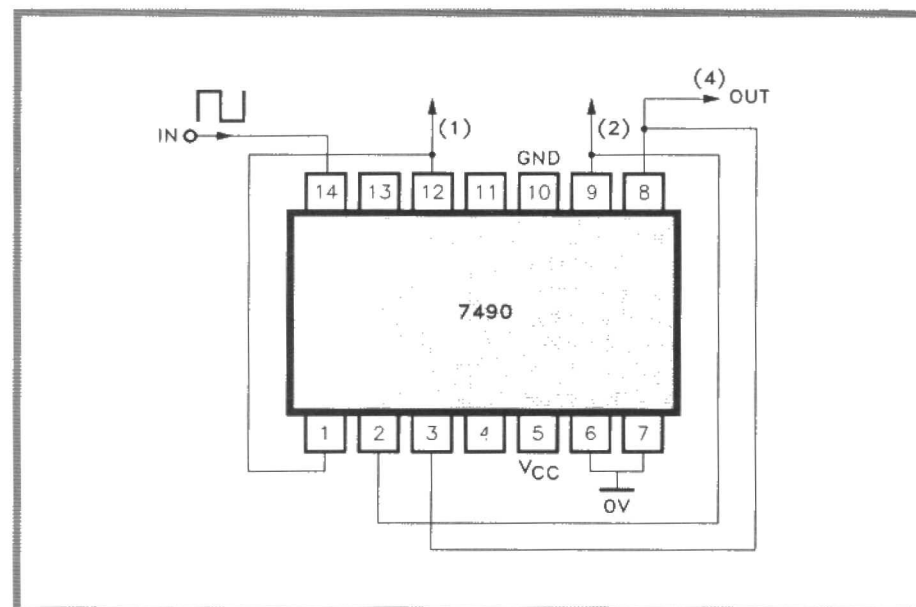


Figure 6. The 7490 connected as a weighted modulo-6 up counter. Note that the Q outputs are identified by their column weightings (bracketed values).

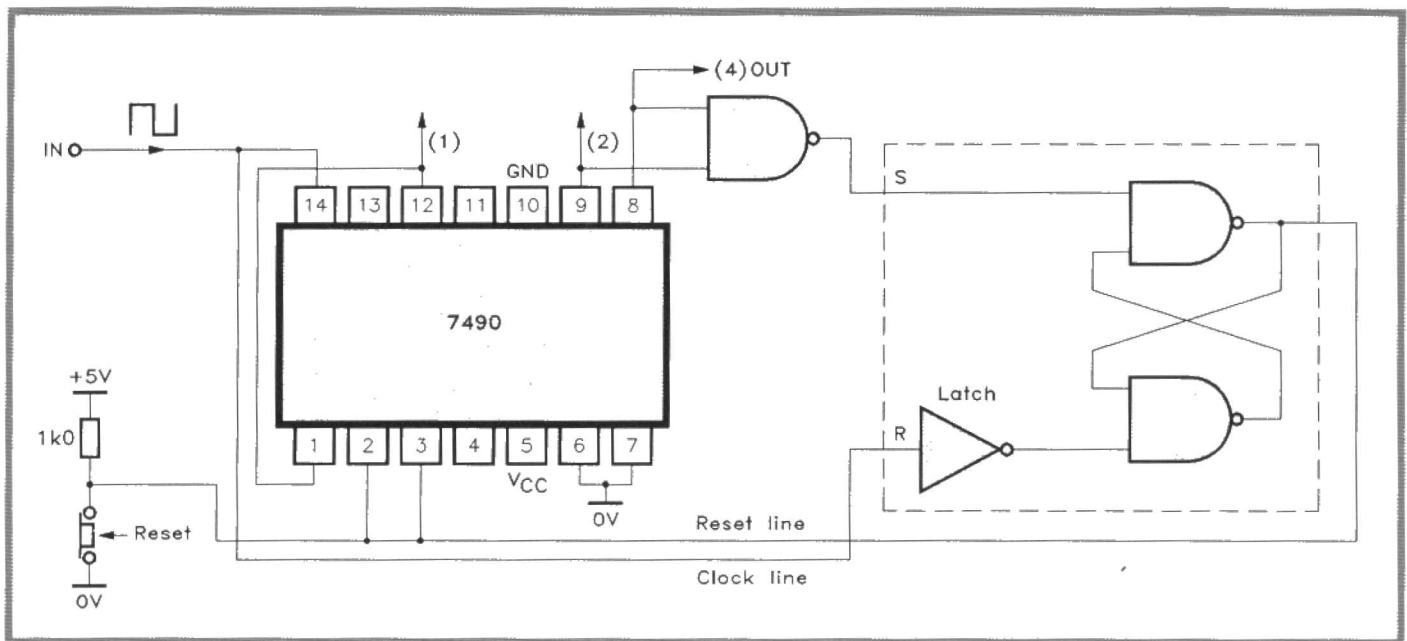


Figure 7. The circuit of Figure 6 modified to have a reset facility.

This is not always the case and Figures 9 and 10 show the other two chips mentioned, the 7492 and 7493 respectively, in use as 'straight' counters. The maximum count of the 7492 is zero to eleven (a modulo-12 counter, itself derived internally by shortening the sequence of a modulo-16 pure binary counter). The 7493 is a pure binary counter with a modulo of 16.

As the two figures mentioned show, the column weightings of the Q outputs, from input to output (LSB to MSB direction), are:

For the 7492 1 2 4 6.

For the 7493 1 2 4 8.

A Few Words of Caution

Because both of these counter chips, in common with the 7490, have a separate 'divide-by-two' section (driven by CLOCK 1 input), to obtain the full count, the Q1 output (pin 12) must be connected to the CLOCK 2 pin of the second section (pin 1). Taking the decade counter as an example, the 'divide-by-two' section drives the clock input of a 'divide-by-five' section. Now everyone knows that, mathematically, it doesn't matter whether you divide a number by two first and then divide by five, or whether you reverse the order of the operations; the result is the same. Unfortunately, when applied to counters, although the division by ten is still obtained (one complete output pulse for ten input pulses), the sequence is different for the two connections. As follows:

1. For the 'divide-by-two' element first: 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, then back to 0000 to repeat. In denary, the sequence is 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, etc.
2. For the 'divide-by-five' element first: 0000, 0001, 0010, 0011, 0100, 1000, 1001, 1010, 1011, 1100, then back to 0000 to repeat.
- In denary, the sequence is: 0, 1, 2, 3, 4, 8, 9, 10, 11, 12, etc.

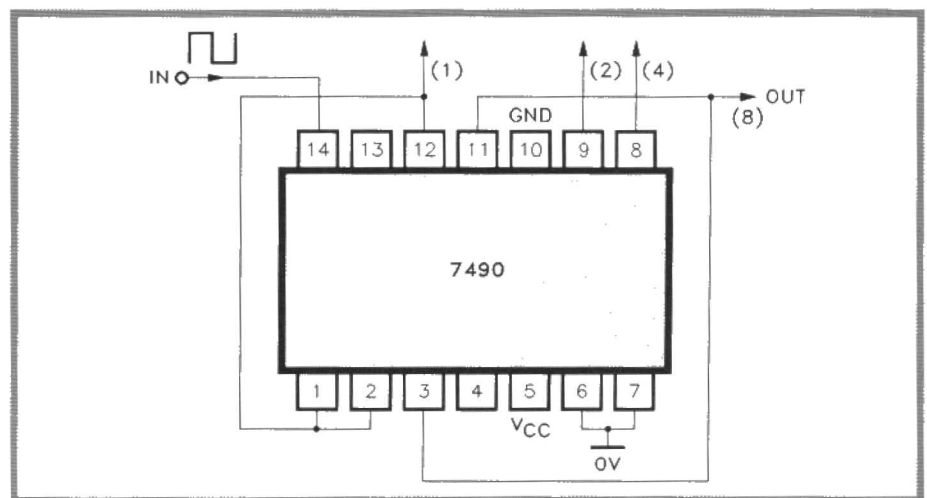


Figure 8. The 7490 connected as a weighted modulo-9 up counter.

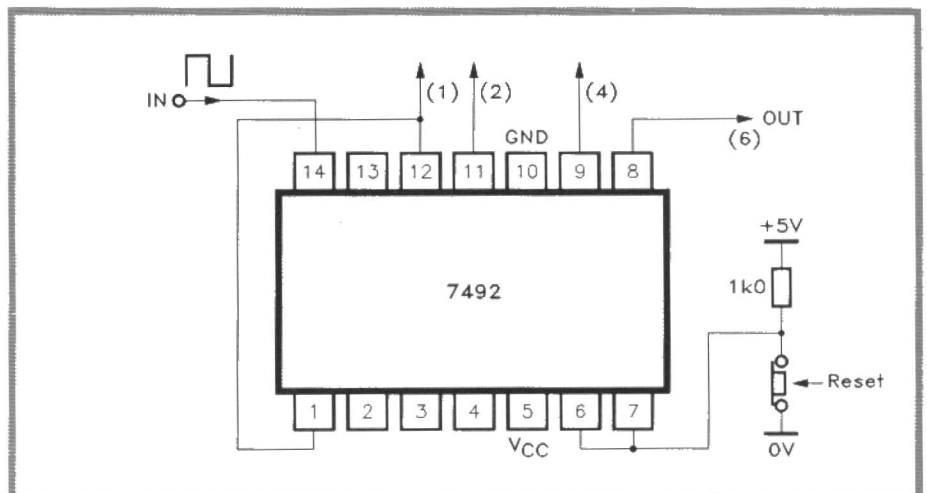


Figure 9. The 7492 modulo-12 counter with reset.

Notice that, in the latter sequence, the first five states are correct; thereafter the sequence jumps because the divide-by-two element is clocked for the first time at this point, as the output of the divide-by-five section goes low.

This does not necessarily mean that the reversed connection has no practical use. As stated it still produces a divide-by-

ten action and furthermore, the output waveform is symmetrical. This is not true of the regular decade counter. The waveforms of Figure 11 show this clearly, but it can also be seen by looking at the Most Significant Bit in the two sequences.

In sequence (1) above, out of the ten states it is low for EIGHT of them and high for only TWO.

Continued on page 51.



BT's Best Kept Secret

by Alan Simpson

Just why BT chose to give their Museum such a low-key profile is a matter best addressed to senior BT management. (Maybe BT director Norman Tebbit should get on his famous bike and pay the Museum a visit.) He would certainly find the visit well worth while. Located close by Blackfriars Bridge in the City of London, the Museum provides a pictorial and hands-on display of the history of the telephone. As the BT brochure says, 'Look in and see what makes a telephone tick (and buzz, bleep, ring and whirr).' But visitors be warned! This is not a quiet museum.

The BT Museum is the only one of its kind in the UK, totally dedicated to telling the story of telecommunications, covering the earliest days of telegraphy to the most recent developments of optical fibre cable. In fact, the museum has examples of just

about every phone there has ever been. In one display, there are a pair of phones which once graced the Rothschild's London residence while in another, there's a special gas mask with built-in earphones and mouth-piece used by telephone operators during the Second World War.

The museum – one of Europe's premier technology showcases – is of particular interest to children (of all ages). The whole history of the industry is here, and so too are pointers as to how the business of the future will be organised. Backed up with video material and plenty of hands-on gadgetry, visitors will not realise they are learning because they will be enjoying themselves too much.

Keeping in Touch

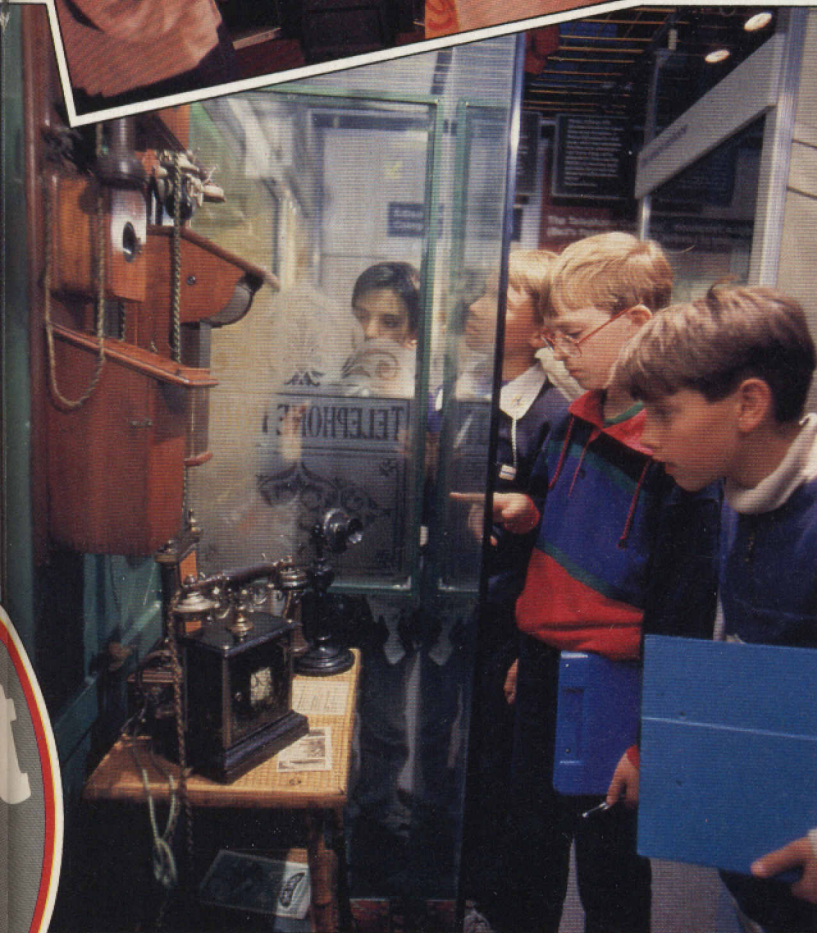
Greek and Roman smoke signals and jungle drums apart, communication can be said to have been invented back in 1684 by the English physicist Robert Hooke, who invented the heliograph and gave the first vivid

outline of the invention with practical details to the Royal Society. But the idea remained just that, an idea, and was not taken up immediately. Then electrical communications got off the ground in 1733 when the Frenchman du Fay differentiated between positive and negative electricity, and a dozen years later, Sir William Watson discovered that it was possible to propagate electric current along metal conductors.

In 1819 Hans Christian Oersted discovered that an electric current in a wire will deflect a magnetic compass needle, a discovery that paved the way for the use of electricity as a means of long distance signalling. It was in June 1837 that William F.



Main pic (left): Satellites are essential for modern worldwide telecommunications. Inset: Very early telephone switchboard. Left: Early 'A' and 'B' button call box. The buttons differentiate between 2 shilling and 1 penny calls. Below: Nostalgic old telephone sets. Bottom left: Alexander Graham Bell. Bottom right: The field telephone was the state-of-the-art in communications during the Great War of 1914-18.



OUT AND ABOUT

Cooke and Charles Wheatstone received a British patent for a five-needle telegraph which was capable of operating over a distance of 1.5km. This was, in fact, the world's first commercial telegraph system. Developments proceeded apace from that date, sprinkled with such luminaries as Samuel Morse and that Scottish inventor, Alexander Graham Bell, the inventor of the telephone. This despite the valid claim of the young German Philipp Reis who, some 16 years earlier in 1860, made a model of a human ear in which a membrane cut from a pig's bladder advanced the role of the electrical telephone. Other notable pioneers included Thomas Edison, Oliver Heaviside, Guglielmo Marconi and Heinrich Rudolf Hertz, whose names live on in the world of electronics and communications.

In the beginning telephones were used to link two definite locations, such as a head office with a factory, but before long, exchanges were built which enabled wires to be connected



as required. The exchange breakthrough came about in 1890 when Almon Strowger, of Kansas City USA, patented an automatic switch which operated directly from pulses of electric current produced by the caller when he dialled. From then on the communications industry has never looked back.

The history of the BT Museum has a somewhat shorter timescale. Opened in 1982, the museum confidently expects to clock-up one quarter of a

million visitors by this time next year. The prize-winning, space capsule-sized exhibition draws on the fully comprehensive collection which BT (and its predecessor, The Post Office) has amassed over the years. The story is told from the very earliest pioneering times to how in recent years the telephone network has rapidly expanded with the advent of new technologies; microwaves, satellites, optical fibres and digital systems.

Within the museum is a special exhibition, 'The Story of Telecommunications', in which its manager, Claire Beswick, has assembled a large collection of museum pieces, many of them in good working order. Young and old visitors alike are fascinated to see how telecommunications has developed from the humble beginnings of making simple connections between two points, into a complex network with links around the globe and reaching far out into space. A highlight of this particular section is a short musical film, 'Fairy of the Phone', which was made in the 1930s to show customers how to make the most of the telephone.



Museum Mission to Spread the Word

According to the Museum manager, Neil Johannessen, the mission of the museum is to provide knowledge and understanding of telecomms and particularly the role of BT in a historical context. "Telecomms began in Britain, development and usage was focused on Britain and still does. In other words, telecomms means Britain, and our public museum reflects this situation. No other communications company or authority in the world could mount such a display, and BT see the museum as being part of their educational and public spirited services - to the world."

One visitor who would feel very much at home - apart, that is, from 'ET' - would be Dr Who. The public telephone box story, police types included, is on show. There is even an old red phone box complete with an original 'Button A, Button B' telephone. It is interesting to note that less

than 90 years ago, 'silence cabinets', as call boxes were then known, were manned by attendants who would place the call, collect the money, and then wait patiently outside. Only in the early 1900s, when kiosks began appearing, did the service become available out of business hours. Early designs varied, but by 1940 the total had risen from 19,000 to nearly 35,000. Now, even in the remotest of areas, one of Britain's 100,000 public pay-phones is never far away. And paying is now easier than ever thanks to the introduction of the popular phonecard and the BT credit card.

Poles and Holes

Exhibits range from the semaphore telegraph of Claude Chappe, 1794 to microwave radio. Along the way there is a priceless collection of early telephones (1885-1910), 1912 PO automatic exchanges, submarine telephony, 'System X' microchip, optical fibres slow scan TV and Satstream and satellites. Many exhibits provide a hands-on opportunity or are supported by a video presentation. You can even get to grips with the Prestel system (but don't expect to get the latest BT share price - it is on a fixed in-house loop). And don't be surprised to find a sizeable collection of cogs and wheels - early telecomms systems were very much pre-micro chip era! As can be expected, the building houses a complete working network - all wiring being overhead.

Fun for Kids of All Ages

While businessmen can play happily with the in-house fax network, visiting school children (who make up 50% of all visitors) will be having a field day. Being let loose with assorted buttons, dials and active phones should provide the accompanying teachers with a welcome break. Even so, BT has seen fit to produce a 'Teacher's Survival Guide' which helpfully lists neighbourhood eating places, there being no catering facilities at the museum. BT stress that their museum caters for a wide range of interests, including history, geography, politics as well as science and physics. As is the style with all major museums, the staff have produced a worthy set of worksheets ranging from Middle/Upper Primary to Lower Secondary school levels.

The museum also boasts a lecture theatre seating up to 40 people. This is mainly used by educational groups, during opening hours, and also where video films on a wide range of telecommunications themes can be seen. In addition the facility can sometimes be booked for business functions and presentations. The museum also has a popular Resource Centre which is an amazing study facility. Here thousands of books, pamphlets, posters and postcards are to be found. A fascinating shop in the foyer of the building offers value for money souvenirs.

Apart from a collection of historic vehicles, which attend vehicle rallies



Laying underground cables in the 1930s.

up and down the country, there are also BT museums at Oxford, Norwich, Edinburgh and Worksop, but visits are by appointment only. Contact your local BT offices for details.

Currently the BT London museum is undergoing a major rebuild where, on completion, even more modern exhibits will be displayed. In BT terms, 'modern' equates to post 1939. However, as Neil states, the original displays were built some ten years ago. The world, and BT in particular, has moved on more than somewhat in that time. It is even rumoured that Mercury may have a place in the new display. "We cannot ignore what is happening outside BT, but we remain aware that BT is the biggest and is likely to remain so for the foreseeable future." What is for sure is that data and mobile comms will have a strong place in the new design. Perhaps also the present Phonepoint facility will have been put on display as one technology that did not quite make the grade.

Whether it is City wheeler-dealers spending their lunch hours at home with a mass array of phones, or nostalgic visitors bemoaning the fate of the much admired red phone boxes, or the very many organised

school visitors, the BT Museum is a place of much interest and not a little surprise. As one group of visitors said as they left, "We had no idea that there was so much to enjoy and discover".

The BT Museum is at 145 Queen Victoria Street, London EC4V 4AT. Open Monday to Friday, 10am to 5pm. (except Bank Holidays). Admission free. The Museum is particularly suitable for disabled visitors. Tel: (071) 248 7444. (Free information line on 0800 289 689.)

BT bonus: readers of 'Electronics' have the chance to win some special prizes kindly donated by The BT Museum. First prize is an all expenses paid visit (including travelling and hotel) for two to Goonhilly Satellite Earth Station in Helston, Cornwall. The venue has a purpose-built visitors centre, which contains an audio-visual show explaining satellite communications, a cinema, static displays and a licensed restaurant. A bus tour of the station, giving a closer look at the giant dish aerials, and a view of the operations control centre, is included in the visit.

Second and third runners-up prize, is a visit (including travelling expenses) for two families to the BT tower.

And as a reader of 'Electronics' you can cut out the voucher below, with which you can claim a free 'Children's Activity Guide' booklet upon presenting the voucher when you visit the museum.

All you have to do to win one of the exciting prizes is to correctly answer the four questions below. The draw will be made, courtesy of the Editors hat, on 31st March, 1992.

Please note that multiple entries will be excluded from the draw. Answers on a postcard (or a sealed-down envelope) to: The BT Museum Contest, The Editor, 'Electronics - The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR. Get communicating!



COMPETITION and Children's Activity Booklet Voucher

All the questions have been sourced from 'The Story of Telecommunications' published by The BT Museum.

- Spot the odd one out:
 - Marconi.
 - Morse.
 - Madonna.
- Which country shared the first international telephone link with London?
 - France.
 - British Guyana.
 - Monaco.
- What does 'STD' stand for?
 - Stand and Deliver.
 - Subscriber Trunk Dialling.
 - Standard Telephone Decode.
- What was 'Early Bird'?
 - The first cuckoo of Spring.
 - The first day shift telephone operator.
 - The first commercial communications satellite.
- What is optical fibre made of?
 - Glass.
 - Ceramic.
 - Hemp.

INTRODUCTION TO Boolean Algebra

Part 3 by Graham Dixey C.Eng., M.I.E.E.

Design of Logic Circuits

The time has now arrived for us to see how we can make some practical use of the algebraic and mapping techniques that we have learnt in the first two parts of this 'mini-series'. Since we are going to design working circuits, we shall need to specify actual hardware. We know that there are five basic gate types: AND, OR, NOT, NAND and NOR. It would be reasonable to think that all we need to do is examine our algebraic expression (once we have got it into the necessary simplified form), and deduce the gate requirements from this by looking at the 'dots, pluses and bars'. So, let us see how this would work out in practice by taking an example. Consider this simplified expression:

$$F = A + \bar{B}.C$$

We shall assume that this has been reached by some minimisation technique – and that now we want a circuit to implement it!

We notice that the first term (A) is ORed with the second term ($\bar{B}.C$), pointing to the need for a 2-input OR gate. The second term consists of \bar{B} (this indicating the need for an inverter if only B is available) ANDed with C – hence these two terms need a 2-input AND gate. Thus, we happily conclude that all we need are three gates; one OR gate, one AND gate and an inverter (NOT) gate. We now draw the circuit for this arrangement, as shown in Figure 1(a). At this point, if we hadn't already appreciated it (!), we might realise that although we only need three gates, we actually need three chips, because each gate is of a different type. As a result, the apparently simple circuit that we have designed is going to occupy an unreasonable amount of board space, cost more, and consume more power than its simplicity warrants.

The situation may not always be as bad as this, since any particular logic block designed using these techniques may be just part of a much larger design.

In such a case, there may be spare gates on the other chips that we can use. Obviously each case must be assessed on its own merits. However, it does point to what is, essentially, an uneconomical approach to circuit design. Let's see if the algebra can help us. A good starting point is to take the original expression and change its form by using de Morgan's theorem. To recap, the three steps are repeated below:

- Replace dots with pluses (or vice-versa).
- Invert each term in the expression.
- Invert the overall expression.

Step (a) is carried out on the two terms A and $\bar{B}.C$ only, followed by steps (b) and (c), giving:

$$F = A + \bar{B}.C \text{ (original expression)}$$

$$(a) A.(\bar{B}.C)$$

$$(b) \bar{A}.\bar{B}.C$$

$$(c) \bar{A}.\bar{B}.C$$

$$\text{Thus, } F = \bar{A}.\bar{B}.C$$

Examination of this expression reveals that it now consists of two NAND terms, one of which is $\bar{B}.C$, while the other is the overall expression itself. This indicates the need for two 2-input NAND gates (one to implement each of these expressions), in addition to two inverters (to invert the variables A and B). It is possible to use any NAND (or NOR) gate as an inverter, merely by 'strapping' all of its input terminals together. This we can do in the above case, leading to a total requirement for four NAND gates. Comparing this with the hardware needs of the earlier AND/OR/NOT circuit shows that we need one gate more but, as all gates are of the same type, only one chip is required as opposed to three, leading to a substantial saving in hardware, board space, power and cost. This alternative design is shown in Figure 1(b).

What we learn from the above exercise is that it is often more economic to use NAND and/or NOR logic rather than a mix of AND, OR and NOT gates. In practice, this approach might be modified slightly by using inverter packages such as the 7408 rather than strapping NAND or NOR gates for this purpose. Again, one should take each case on its merits.

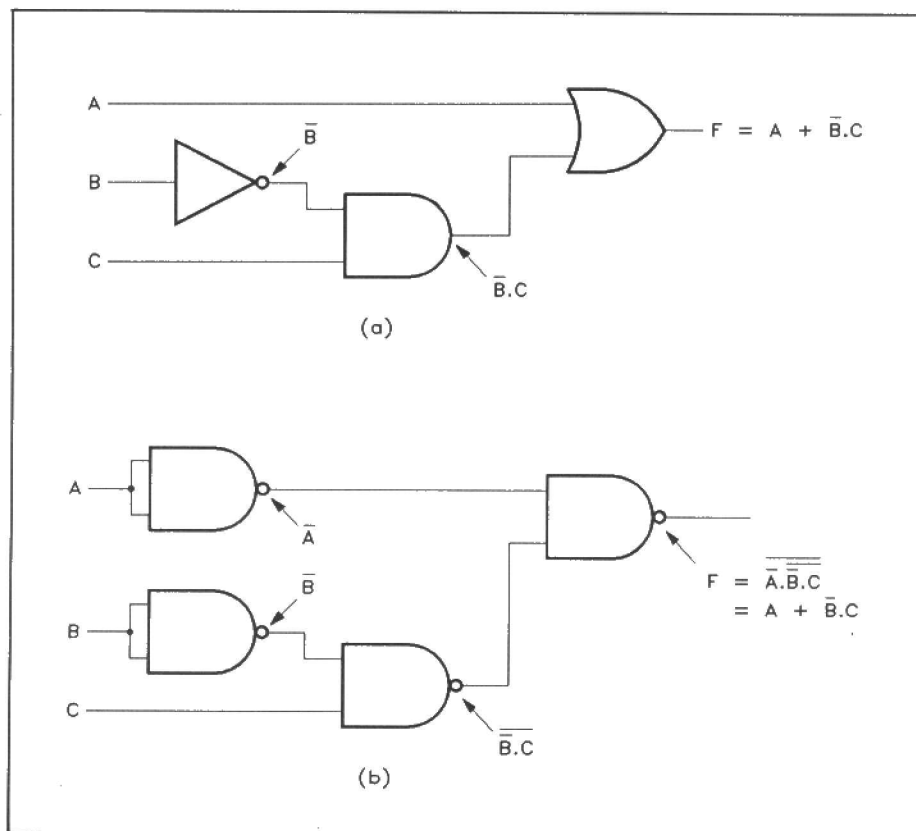


Figure 1(a). The AND/OR circuit for the function $F = A + \bar{B}.C$.
Figure 1(b). The NAND circuit for the same function.

The Design of an XOR Circuit

It will be remembered that exclusive-OR (XOR) differs from the normal OR function (sometimes called 'inclusive-OR') in that the output is zero when both inputs are at logic 1. The XOR function is actually available in a 'quad' (four gates on one IC) TTL-family package, known as the 7486. However, it is a useful design to consider as it helps to illustrate how it is possible to employ the occasional little 'trick' to improve a design, provided that one has either the experience, or perhaps the intuition. Let us carry out a design plan similar to the one done previously. We start by writing down the algebraic statement for this function, namely:

$$F = \bar{A}.B + A.\bar{B}$$

Applying de Morgan's to it gives the following result:

$$F = (\bar{A}.B).(\bar{A}.B)$$

We note that this contains three NAND terms and two NOT terms; it will obviously require five gates to implement it. Nothing wrong with that, you say, except that there are only four 2-input NAND gates on a 7400 chip, and therefore the design needs two chips, with three gates left unused on one of them. This assumes that we use NAND gates (with strapped inputs) for the two inverters. If, in some way, we could eliminate one of the gates, we could squeeze our XOR function onto a single 7400 chip. The following shows how it can be done:

On Figure 2, the Karnaugh map for the

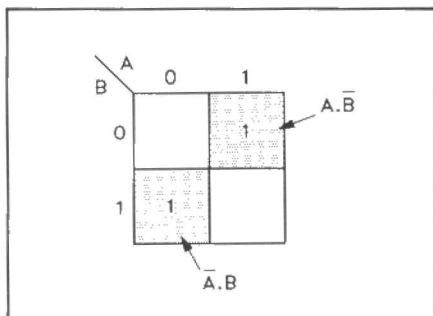


Figure 2. The Karnaugh map for the circuit.

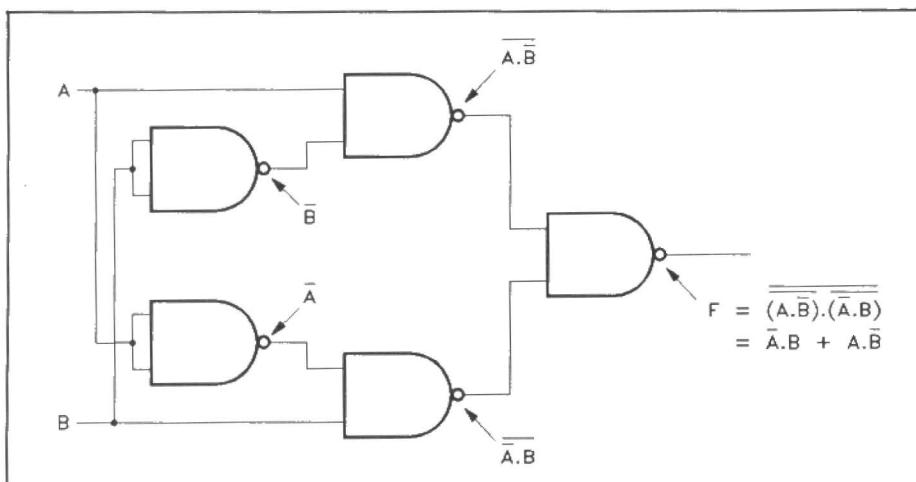


Figure 3. A five-gate circuit for the XOR function.

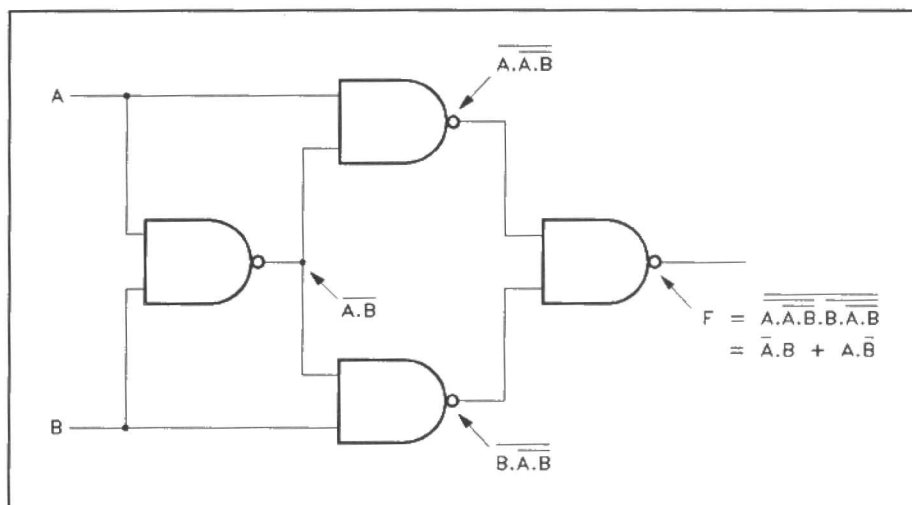


Figure 4. A more economical four-gate XOR circuit.

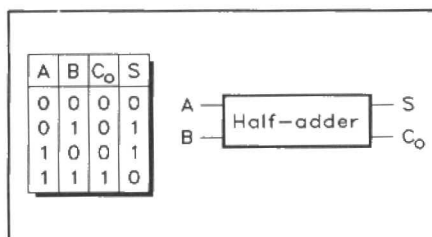


Figure 5. Truth table and logic block for the half-adder circuit.

the XOR function (shown in Figure 3), two of the squares are used for the two terms ($\bar{A}.B$, $A.\bar{B}$) of the function; these are shown shaded for emphasis. By applying simple logic to this situation, we could make the following statement (with reference to Figure 2):

If F = 'the shaded squares', then F is NOT equal to the 'unshaded squares'; or, put another way, NOT- F = the 'unshaded squares'. The unshaded squares represent the terms $\bar{A}.B$ and $A.B$, so what we are saying is that $F = \bar{A}.B + A.B$. De Morgan can be applied to this expression as follows:

$$\begin{aligned} \bar{F} &= \bar{A}.B + A.B \\ &= (\bar{A}.B).(\bar{A}.B) \end{aligned}$$

(using de Morgan)

$$\begin{aligned} \text{Therefore, } F &= (\bar{A}.B).(\bar{A}.B) \\ &= (A + B).A.B \end{aligned}$$

(cancelling the 'bars')

$$\begin{aligned} &= (A + B).A.B \\ &= A.A.B + B.A.B \end{aligned}$$

(using de Morgan again)

$$\begin{aligned} &= A.A.B + B.A.B \\ &= A.B + A.B \end{aligned}$$

(expanding the brackets)

What we now have is a sum of products expression containing a common factor ($\bar{A}.B$) in each term. It will be seen shortly how useful this is. What we must do now is to put the above expression into a form suitable for NAND implementation. To do this, we apply de Morgan (yet again!), this time to the whole expression, giving:

$$F = (\bar{A}.B).(\bar{A}.B)$$

This contains five NAND terms, but two of them are identical and will therefore use the same gate. This means that we shall need only four NAND gates. As a result, we can implement the design using a single IC. The final design is shown in Figure 4.

Design of a Half-adder Circuit

The function of a 'half-adder' circuit is to add together two binary digits, producing their sum in addition to any 'carry' bit that may occur. It differs from the 'full-adder' in that the latter also has the provision for including the 'carry in' from a previous addition in the summation. Essentially, the half-adder merely implements the basic rules of binary addition. With only two bits to add, there are only four possible results:

$$0 + 0 = 0; 0 + 1 = 1; 1 + 0 = 1; 1 + 1 = 10$$

Only the last addition, shown above, generates a carry to be brought forward into the next column. The above results can also be expressed by a truth table (Figure 5). This figure also shows the logic block showing that there are two inputs (the variables A and B), and the two outputs which express the result. Each of these outputs will have its own algebraic expression. These can be extracted from the truth table in the usual way, by noting for which combinations of A and B the relevant output is logic 1.

For the sum (S) output:

$$S = 1 \text{ for } \bar{A}.B + A.\bar{B}; (S = \bar{A}.B + A.\bar{B}),$$

For the carry out (C_o) output:

$$C_o = 1 \text{ for } A.B; (C_o = A.B)$$

In this particular case, note that the expressions are incapable of any further simplification. If that had not been the case, then we should have used either

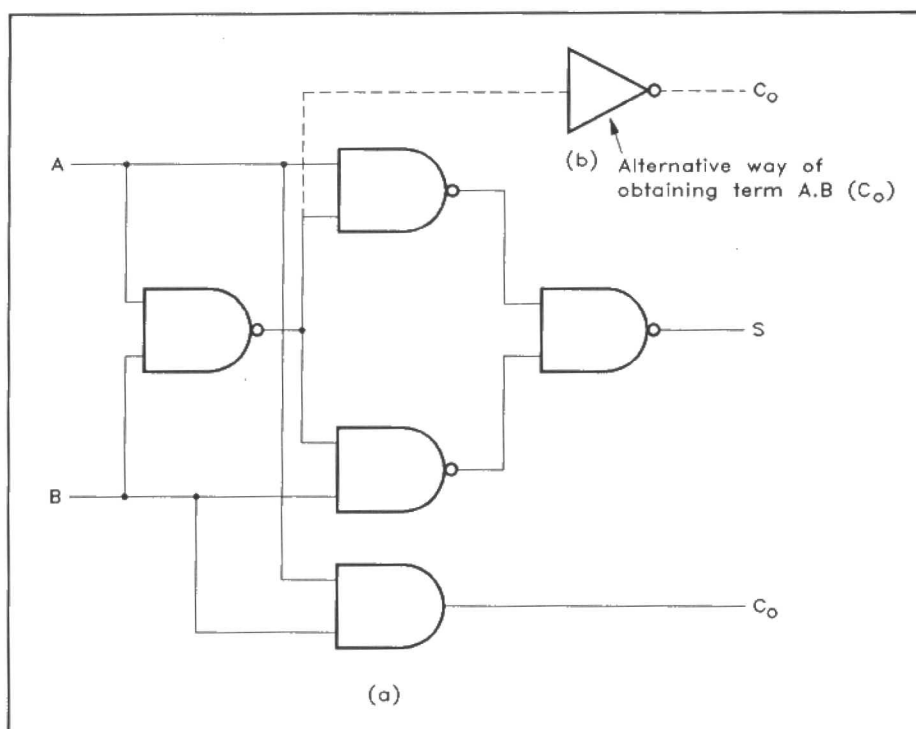


Figure 6(a). The half-adder circuit with C_o obtained by the direct use of an AND gate.
Figure 6(b). The half-adder circuit with C_o obtained by inverting the common term $\overline{A.B}$.

algebraic or mapping methods in order to reduce them even more. Furthermore, it is quite easy to recognise that S is the exclusive-OR of A and B, while C_o is simply the AND of these two variables. The XOR function has already been described (Figure 4), and all we need to do is include the AND function. There are two ways in which we can do that:

Either we actually use an AND gate, as in Figure 6(a), or we can make use of the fact that the circuit of Figure 5 already contains the complement of this required term, namely the common term $\overline{A.B}$ developed by the leftmost gate. All we need to do is to invert this term to obtain $A.B$. This latter method is shown in Figure 6(b). The number of gates (and chips) used is the same in both cases. However, this will not always be so and there is also the question of whether we want to adhere to the general use of a single logic type (e.g. all NAND gates) as far as possible.

As a further example of this philosophy, and on an even simpler plane, one may remember that a flip-flop has two outputs, known as Q and \overline{Q} . In a sequential logic circuit – a counter or register – the flip-flop Q outputs might be given the variable names A, B, C, D, etc. Thus, if A is needed, for example, there is no need to use an inverter from the A output, since the inverted form already exists at the \overline{Q} output (See Figure 7).

Designing a 2 to 4 Line Memory Decoder

A memory chip is invariably selected by taking one of its pins, usually termed CE or CS, to logic 0. The drive to this pin is obtained from one of the outputs of a memory decoder whose inputs are particular address lines, according to the design of the system. The simplest type of memory decoder has two inputs (giving rise to four possible combinations) and, hence has four

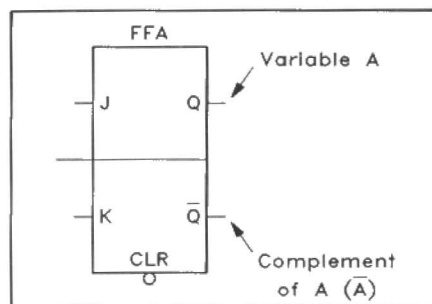


Figure 7. Using the \overline{Q} output of a flip-flop to obtain the complement of a variable.

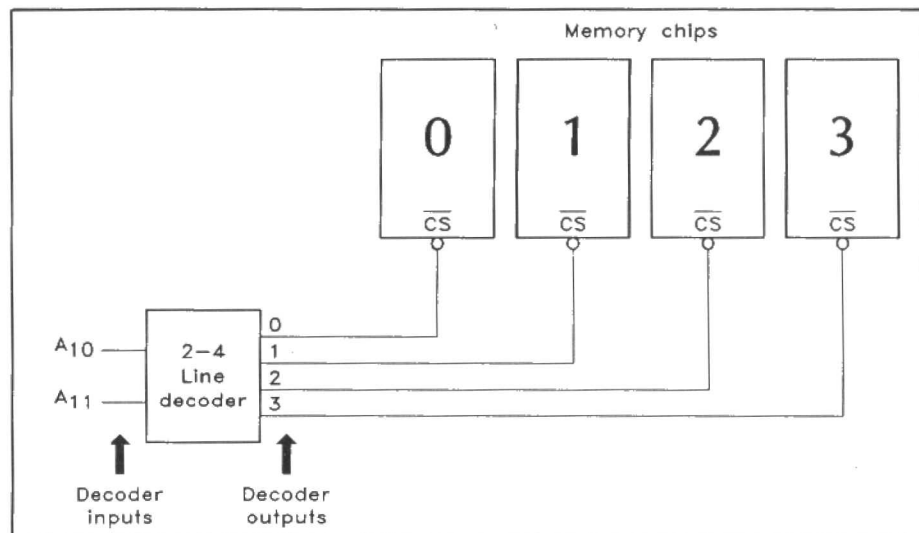


Figure 8. Use of a 2-4 line memory decoder.

outputs, each to select one of four memory chips. This arrangement is seen in Figure 8. The inputs to the decoder are the two address lines A10 and A11. The logical relations between inputs and outputs are shown in the truth table of Figure 9.

Note that only one output is at logic 0 at any one time. Therefore, for each column, there are always three 'ones' and a single 'zero'. We could draw a 2-variable Karnaugh map for the logic to

select each memory chip, simplify it in the usual way and so obtain a minimal expression. From this we could deduce the hardware requirements. If we were to do this for output '0', for example, we should find that the only square on the map that wasn't filled with a 'one' was that for the term $\overline{A11.A10}$. Thus, the function $F(0)$ (represented by the three squares mentioned) has a complement $F(0) = \overline{A11.A10}$. Therefore, instead of drawing the map, we can make use of this fact instead.

That is, if $F(0) = \overline{A11.A10}$,
then $F(0) = \overline{A11.A10}$.
= $A11 + A10$ (using de Morgan's theorem).

This shows that $F(0)$ is the OR function of A11 and A10 which we might have recognised, incidentally by looking at the column for this particular function. As clever as we may be in recognising this fact, it isn't always in our best interests to change the form of the expression in this way. The NAND form is much more convenient, as we have already seen (and shall see again). Let us look at the other columns:

For the second memory chip,
 $F(1) = \overline{A11.A10}$,
therefore: $F(1) = \overline{A11.A10}$

For the third memory chip,
 $F(2) = \overline{A11.A10}$,
therefore: $F(2) = \overline{A11.A10}$

For the fourth memory chip,
 $F(3) = \overline{A11.A10}$,
therefore: $F(3) = \overline{A11.A10}$

| Inputs | | Outputs | | | |
|--------|-----|---------|---|---|---|
| A11 | A10 | 0 | 1 | 2 | 3 |
| 0 | 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 0 |

Figure 9. Truth table for the 2-4 line memory decoder.

exercise. There are also other little tricks that will be found in books on the subject. The one that will be demonstrated here is a very simple method that, with patience (and enough paper!), can be used to prove, or disprove, identities as complex as you like. What we do is to form a truth table, with columns for each of the functions whose equality we are trying to prove. If, having done this, the pattern of 'ones' and 'zeroes' in these two columns is the same, then the functions are equal. Let us take a case to illustrate this:

EXAMPLE: There is a proposition that $A + \bar{A}.B = A + B$ which we should like to verify. It is not immediately obvious that these two functions are equal. We should, therefore, have to try various 'lines of attack' until we get the right answer. However, we shall avoid this 'suck it and see' approach, and draw up a truth table for the two functions. This is shown in Figure 12.

Starting at the left, the first two columns (i) and (ii) give the four possible combinations of the variables A and B . Since one of the functions contains \bar{A} , a column (iii) is provided for this also. This is obviously just the inverse of the column for A . Because there is a function that uses \bar{A} (it is ANDed with B), we provide a column (iv) for it as well. The values in this column are nothing more than the AND function performed between the values in columns (iii) and (ii), line by line. Is this clear? Looking at these two columns, it will be seen that the only line, for which the value is 'one' in both cases, is the second line. Thus, this line is the only one for which the value in column (iv) is a 'one', this being the result of ANDing two ones, of course. If we now OR the values in column (iv) with those in column (i), we shall be obtaining the logical result of the function $A + \bar{A}.B$, line by line. This is seen in column (v), and is the first of the required functions. The final column is for the other function

| (i) | (ii) | (iii) | (iv) | (v) | (vi) |
|-----|------|-----------|-------------|-----------------|---------|
| A | B | \bar{A} | $\bar{A}.B$ | $A + \bar{A}.B$ | $A + B$ |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 1 |

↑ ↑
These two columns identical,
hence $A + \bar{A}.B = A + B$

Figure 12. Truth table to prove the identity $A + \bar{A}.B = A + B$.

$A + B$, which is obtained by ORing columns (i) and (ii), line by line. Since the two columns (v) and (vi) are the same, the proposition is proved.

Now, if you think that you've got the idea, why not use it to prove de Morgan's law that $\bar{A} + \bar{B} + \bar{C} = \bar{A}.B.C$? It should be easy!

The Principle of Duality

In Boolean algebra, every expression has a 'dual'.

To form the dual of an expression, merely substitute dots for pluses (and vice-versa) in all the terms, and for all the variables. Note that this is not the same as using de Morgan's theorem, since no inverting is carried out.

For example, the dual of $A.B$ is $A + B$
the dual of $(A + B).(C + D)$ is $A.B + C.D$
the dual of $A.\bar{C} + B.C$ is $(A + \bar{C}).(B + C)$

One thing that duality will obviously do is to change the form of a sum of products expression into that of a product of sums, and vice-versa. Note this carefully; duals are NOT EQUAL, therefore, duality must always be used an EVEN number of times, if the final expression (which might now be in quite a different form) is to be equal to the original expression. The object of duality

is to change the form of an expression that will not obviously simplify (or would involve an unnecessary amount of work in so doing) into a form that is easy to simplify. If the dual of this simplified expression is now taken, the first and last expression (though different in form), are equal.

To take an example:
Simplify $(A + B).(A + \bar{C}).\bar{B}$

This could obviously be simplified by multiplying out the brackets (thus obtaining a sum of products form with many terms), and then factorising to simplify the expression. More work than is really necessary, as the alternative method, using duality, will show:

Writing down the expression again:
 $(A + B).(A + \bar{C}).\bar{B}$

Writing down its dual: $A.B + A.\bar{C} + \bar{B}$

A is common to the first two terms, and so factorise, giving:

$A.(B + \bar{C}) + \bar{B}$

Writing down the dual of this: $(A + B.\bar{C}).\bar{B}$

Now multiply out the brackets:
 $A.\bar{B} + B.\bar{C}.\bar{B}$

Which equals: $A.\bar{B}$

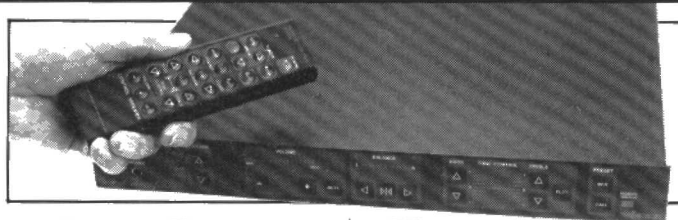
(since the second term contains $B.\bar{B}$, which equals zero).

Two points should be noted. The first is that we took the dual expression TWICE, satisfying the requirement that it should always be taken an EVEN number of times. Secondly, we used one of the basic axioms ($B.\bar{B} = 0$), given in Part One of this series.

This now completes our introduction to Boolean algebra. It is hoped that readers have found it both interesting and of some practical help as well. It should certainly have provided both a basis for further study, as well as a convenient reference.



In next month's super issue of 'Electronics - the Maplin Magazine', there are some really great projects and features for you to get your teeth into! The April issue is on sale 6th March, available from Maplin's regional stores and newsagents country-wide, and of course by subscription (see page 13 for details). To whet your appetite, here's a taster of just some of the goodies on offer:



VELLEMAN DIGITAL PREAMPLIFIER

A review of (and constructional details for) the versatile and attractive Velleman preamplifier. Instead of wear-prone and signal-degrading manual switches, this unit features reliable contactless electronic switching - and can be used with an optional remote control.

VIDEO PROCESSING SYSTEMS

Due to popular demand, in the April issue we start a new, easy-to-follow and fascinating series which delves into the all-encompassing world of video. Part One describes the basics, which include a description of the video waveform and its composition.

VIRTUAL REALITY

Take a leap into the exciting computer-generated world of Virtual Reality! In this feature, its potential is discussed, along with current and future developments in this area.

VOLTAGE REGULATORS

Three-terminal voltage regulators enable low-to-medium current DC power supplies to be easily and

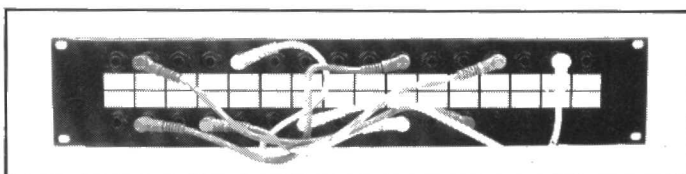
cheaply constructed. In April's Data File, these undeniably useful devices are covered in depth.

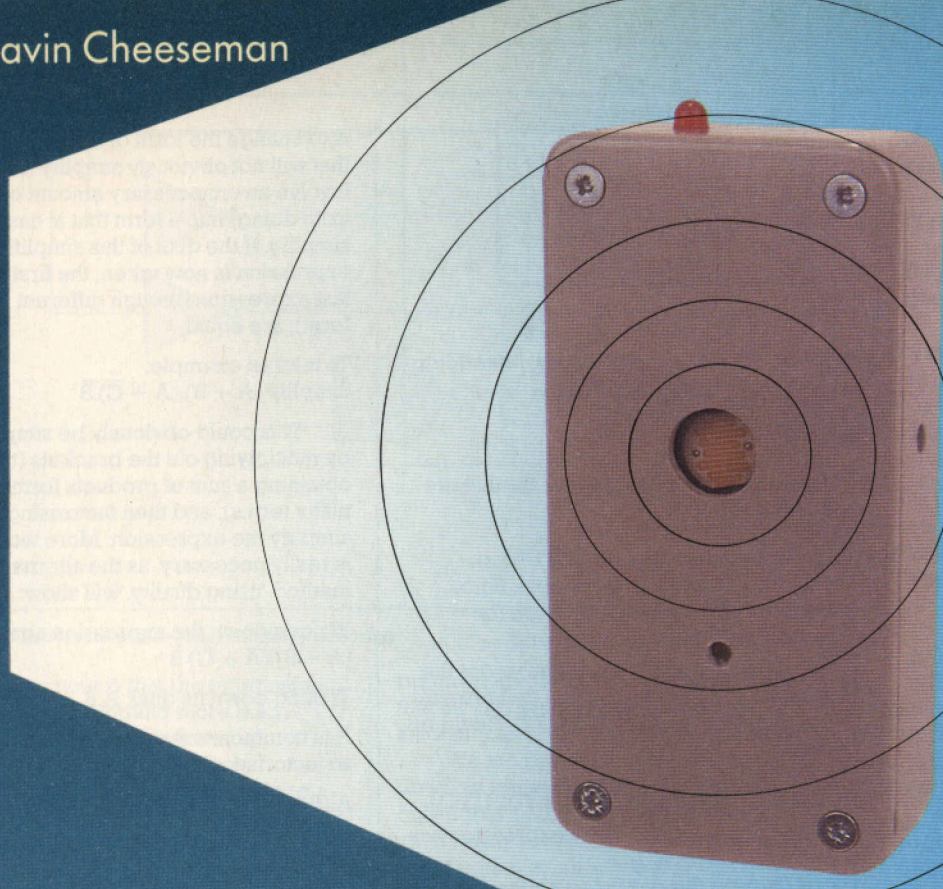
MODERN BRIDGE CIRCUITS

In this new series, we look at the theory and practice behind these circuits, which are at the heart of most accurate resistance, capacitance and inductance measuring devices.

16-WAY AUDIO PATCHBAY

An elegant and practical solution to those tiresome 'platefuls of spaghetti', normally associated with the electronic instruments, effects units and other audio equipment encountered in home (and semi-professional) studios.





PEEP ALARM

The Peep Alarm is a light-operated sounder, simple but effective in its operation. In a dark environment, the unit remains quiet, and is for all practical purposes switched off. However, when light falls on the alarm's photosensor, the unit emits a loud, shrill tone. In addition, a light emitting diode (LED) illuminates, providing secondary indication that the circuit has been triggered. An on-board light sensitivity control is included in the design to allow operation in a variety of situations, over a range of light levels.

Circuit Description

Figure 1 shows the circuit diagram of the module. The circuit is based around a 4093BE CMOS quad Schmitt NAND IC (IC1). Diode D1 prevents damage to the circuit if the battery is unintentionally connected the wrong way round. The photosensitive device used is an ORP12 light dependent resistor (LDR), chosen for its wide change in resistance relative to a comparatively small change in light level. Together with R1, R2 and RV1, LR1 forms a potential divider. As light falls on LR1, its resistance decreases, reducing the voltage at the centre of the divider chain. When the voltage level drops to the switching threshold of IC1a, the output of the gate switches from low to high. The output of IC1a is fed to IC1b, which forms a gated oscillator. When the logic level on pin 5 is high, the oscillator operates, but when the level is low, the oscillator is disabled. The operating frequency of the oscillator is determined by R3 and C1, the supplied values of R3 and C1 generating a frequency of approximately 4.6kHz. IC1c forms an inverting buffer between the oscillator and sounder PZ1. Diode D2 is used to protect IC1 from any high voltage spikes which the sounder may produce. The output of IC1a is also fed to IC1d, which drives light emitting diode LD1. Resistor R4 limits the current through the LED.

FEATURES

- ★ Low Quiescent Current Consumption
- ★ Operates From 9V PP3 Battery
- ★ Simple Effective Design
- ★ Fibreglass PCB
- ★ LED Alarm Indicator
- ★ Light Sensitivity Control
- ★ Reverse-Polarity Protection

APPLICATIONS

- ★ Door Open Reminder
- ★ Case Alarm

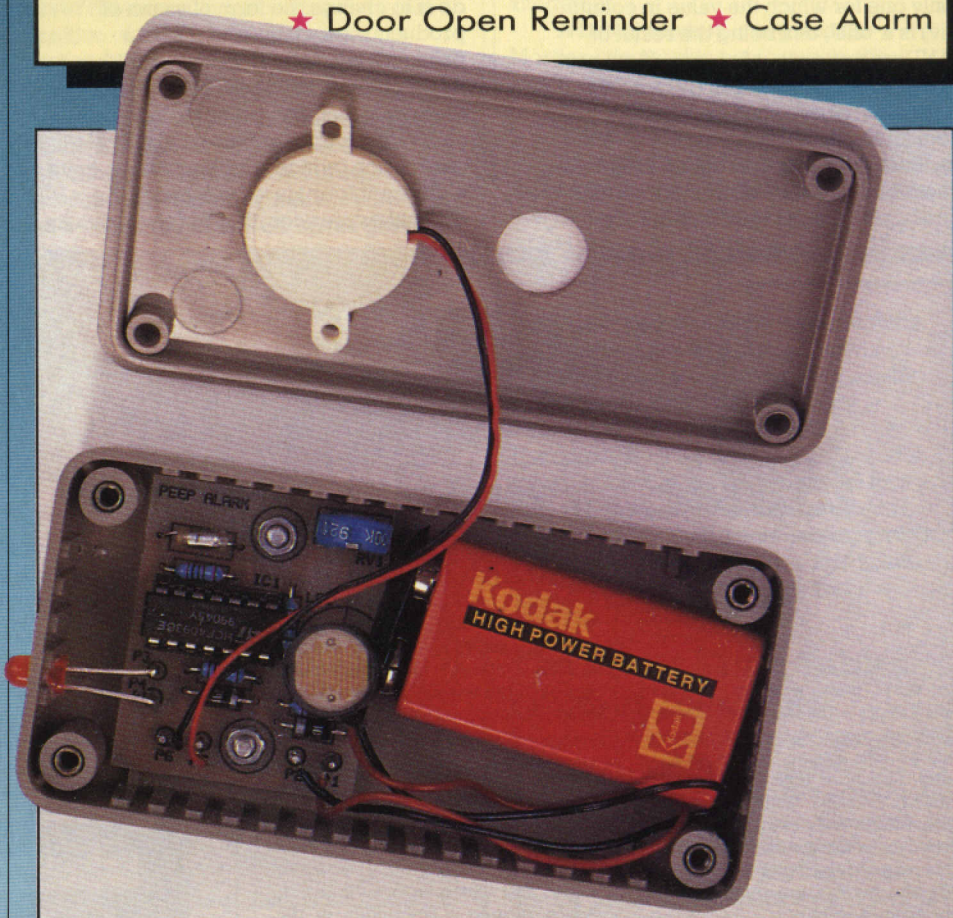


Photo 1. Assembled Peep Alarm with lid removed, showing positioning of PCB and battery.

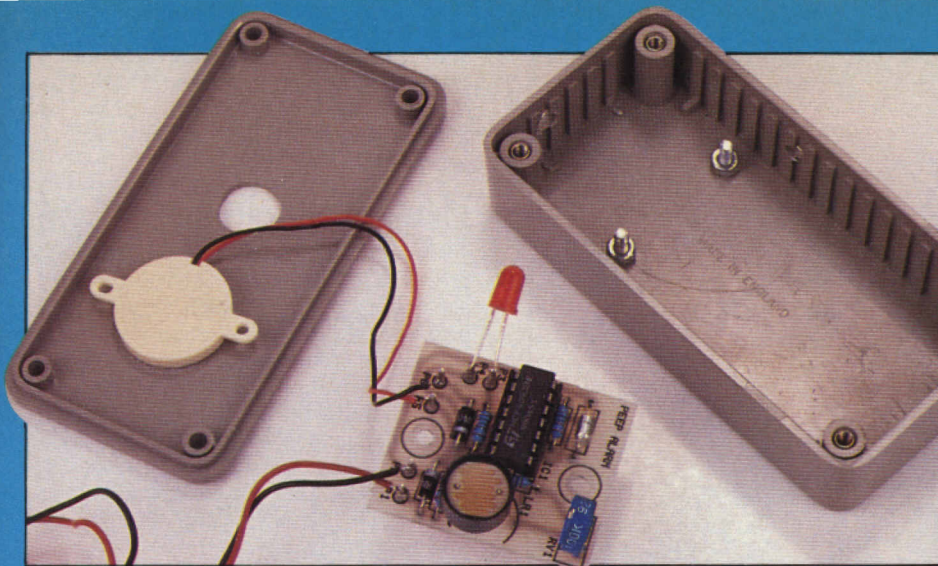


Photo 2. The complete Peep Alarm prior to final assembly.

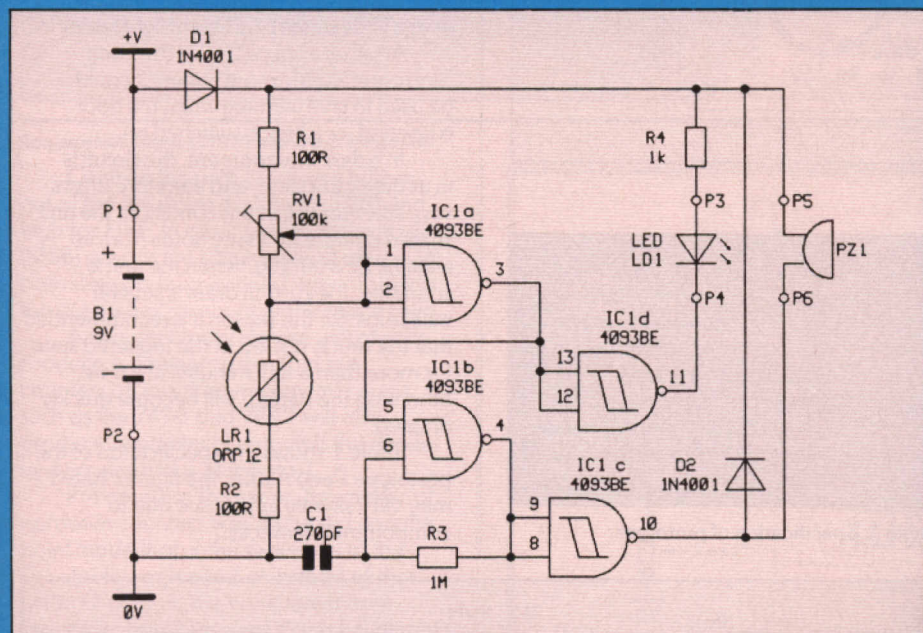


Figure 1. Circuit diagram.

Construction

The design uses a high quality, single-sided, glass fibre PCB, with a screen-printed legend, see Figure 2. Insert and solder the components onto the PCB, referring to the component legend, starting with resistors R1 to R4 and capacitor C1. Fit the IC socket, ensuring that the position of the notch at one end of the socket corresponds with that on the component legend. Do not fit the IC at this stage. P1 to P6, the PCB pins, are inserted into the PCB from the track side using a hot soldering iron. The head of the pin should be heated to the extent that very little pressure is required to press it home into the PCB. After the pin has been inserted it may then be soldered. Preset resistor RV1 is inserted so that its case corresponds with the outline on the component legend. When fitting D1 and D2, it is important that the correct polarity is observed; the negative end of the diode, indicated by a band at one end of the component, should be inserted so that it matches the band printed on the legend. Light dependent resistor LR1 should be mounted at a height of 10mm above the PCB, as shown in Figure 3. IC1 may then be inserted into the socket. The IC should be positioned so that the notch at one end of the component

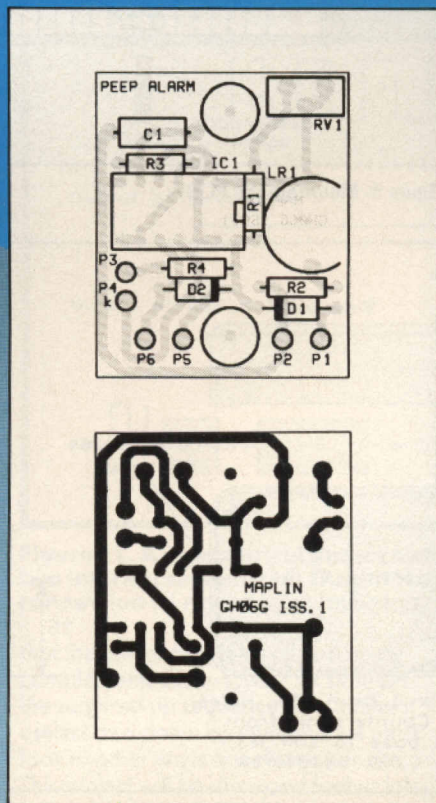


Figure 2. PCB legend and track.

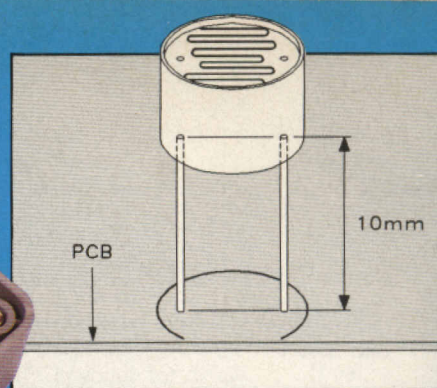


Figure 3. Mounting LR1.

corresponds with that in the socket. The battery clip is wired to P1 (red) and P2 (black). The light emitting diode, LD1, is soldered between P3 (anode) and P4 (cathode). The cathode of the LED is indicated by a flat edge on the side of the component body, and by the shorter of the two leads. PZ1, the piezo sounder, is wired between P5 and P6. All connections are illustrated in Figure 4, together with assembly information.

Housing

The Peep Alarm is housed in a small plastic box, which is included in the kit. The PCB is held in the box using M3 nuts and bolts, as shown in Figure 5. Additional M3 nuts are used as spacers under the PCB. The easiest method of assembly is to first insert the bolts into the underside of the box. Thread an M3 nut onto each of the bolts and screw down until locked into position. Now fit the PCB over the bolts, and lock it into place using a second set of M3 nuts. It is necessary to remove some of the moulded plastic guides from the end of the box to allow the battery to fit comfortably. It is also necessary to drill several holes in the box. Apart from those used to mount the PCB, holes must be drilled in the case lid, so that light can fall on LR1, and to allow the buzzer to be heard as loudly as possible. The drilling details are shown in Figure 6. Piezo sounder PZ1 should be held in place on the inside of the box lid (as shown in Photo 2), using the epoxy adhesive supplied in the kit. This device should be pressed, as tightly as possible, against the lid until the adhesive sets. Note: the hole in the centre of the sounder must correspond with the hole in the box lid.

Testing

Before testing the module, it is a good idea to double-check your work to make sure that all of the components are inserted correctly, and to ensure that there are no dry joints, or solder bridges between tracks. If all is well, connect a 9V alkaline type PP3 battery to the battery clip, observing the correct polarity. Place the module in a well-lit area, and adjust preset resistor RV1 until the sounder emits a loud high-pitched tone. If the unit is then placed in the dark (i.e. there is very little light falling on the sensitive surface of LR1), PZ1 should stop sounding. During the period when the unit is sounding, LD1 should glow, providing a secondary indication that the unit has been triggered. If you do not require LD1, this component may be omitted without any detrimental effect on the operation of the circuit. RV1 adjusts the sensitivity of the unit to light,

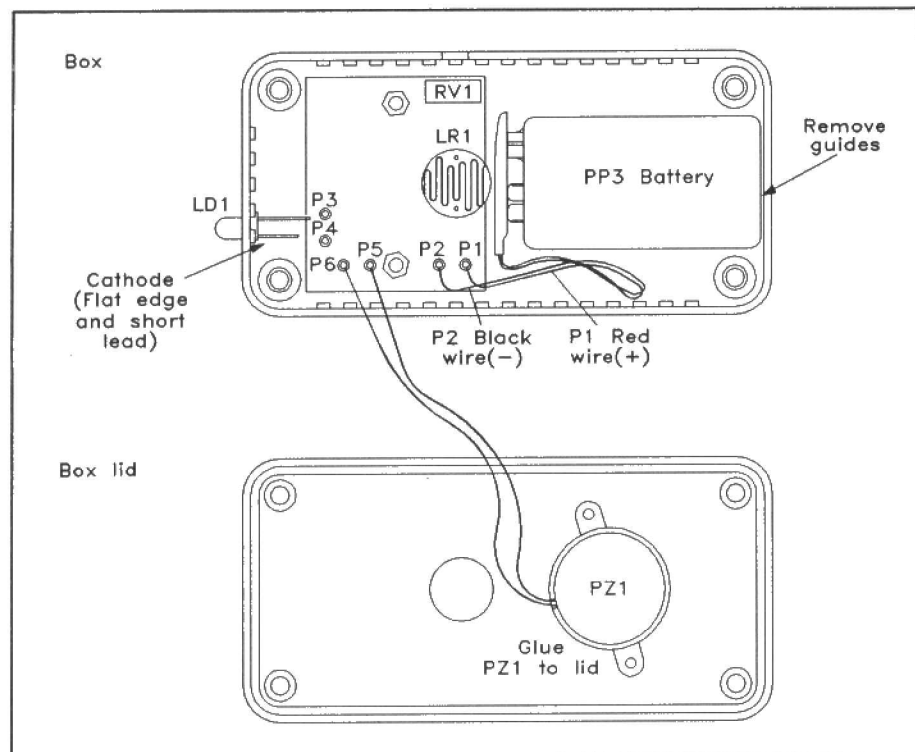
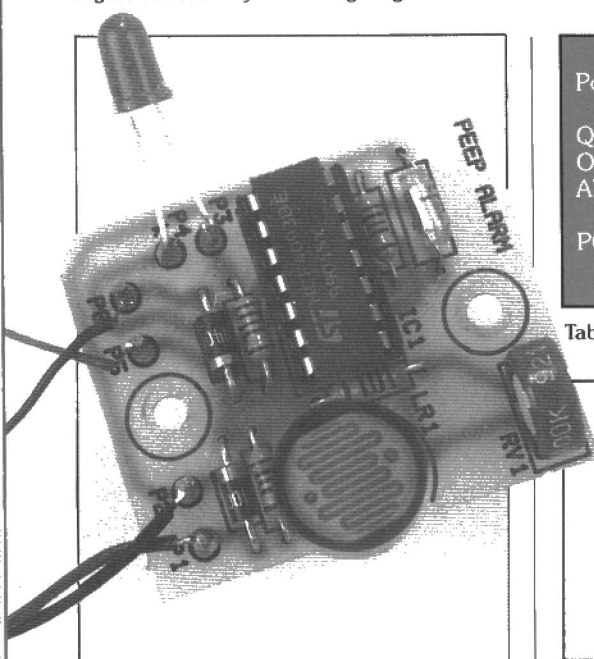


Figure 4. Assembly and wiring diagram.



The assembled PCB

| | |
|--------------------------|---------------------------------|
| Power Supply: | 9V alkaline type PP3 battery |
| Quiescent current drain: | less than $1\mu\text{A}$ |
| Operating current: | 14mA |
| Alarm Frequency: | 4.6kHz |
| PCB Dimensions: | approximately 41 x 34mm |

Table 1. Specification of prototype.

and in practice it is necessary to adjust this control for optimum performance in any one particular situation. The circuit is set for maximum sensitivity when RV1 is fully anticlockwise.

Using the Module

The Peep Alarm may be used in a variety of applications requiring a light-operated alarm. In a typical application, it could be used to provide an indication that a cupboard or case is open; a situation that could arise from an attempt to gain unauthorised access, or simply by leaving it open unintentionally. The alarm is purely intended to give a local indication, and is not designed to be audible over a long distance. Obviously the alarm will only operate in an environment where there is a significant increase in light level when the cupboard or case is opened. The Peep Alarm is, however, designed to operate over a wide range of ambient light levels.

Another application for the Peep Alarm is in a dark-room, where it could be used to give warning when the door is opened, or a light is switched on.

In a dark environment, the circuit is in its quiescent state, and therefore draws very little current; in this condition, the unit should operate for many hours from an alkaline PP3 battery. When the unit is sounding, the current drain is several milliamps; for this reason it is recommended that the unit is not left in the triggered state for more than a few minutes at a time, otherwise the battery will become quickly drained.

Table 1 shows the specification of the prototype Peep Alarm; the figures stated may vary slightly in practice due to component tolerances.

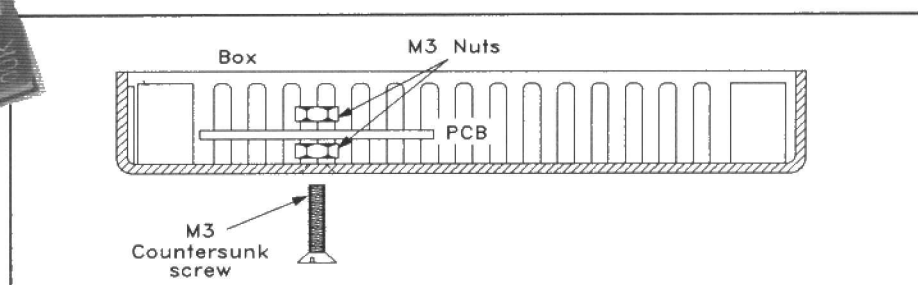


Figure 5. Mounting the PCB.

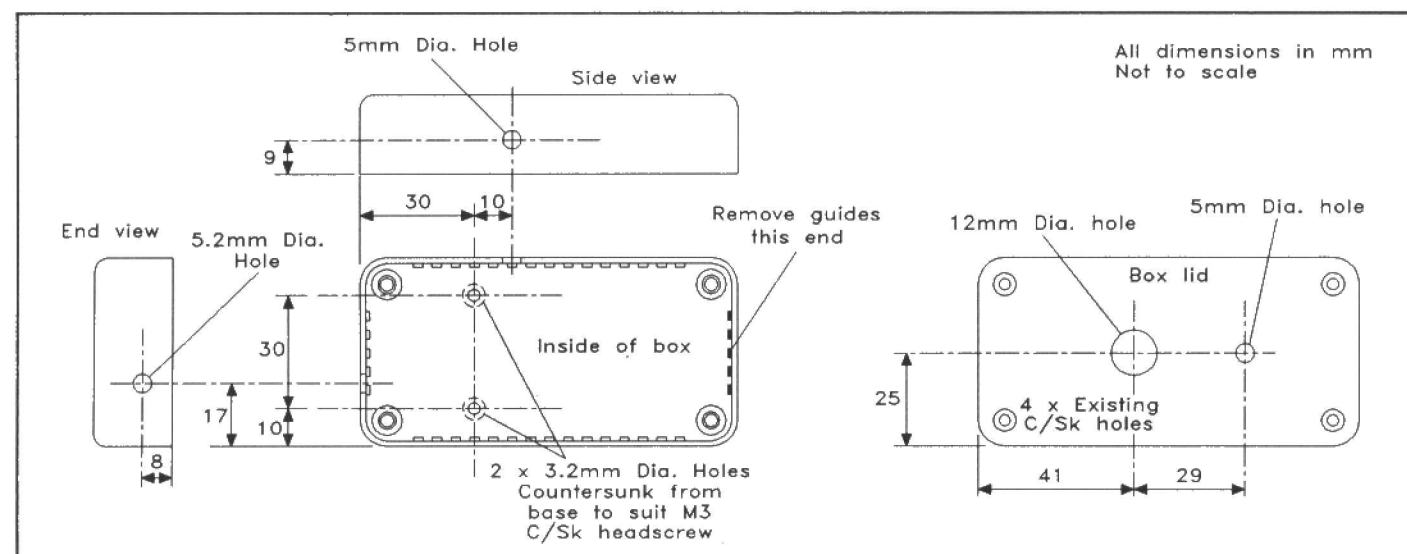


Figure 6. Drilling details.

PEEP ALARM PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless specified)

| | | | |
|------|----------------------|---|---------|
| R1,2 | 100Ω | 2 | (M100R) |
| R3 | 1M | 1 | (M1M) |
| R4 | 1k | 1 | (M1K) |
| RV1 | Vrt Encl Preset 100k | 1 | (UH19V) |

CAPACITORS

| | | | |
|----|----------------------|---|---------|
| C1 | 1% Polystyrene 270pF | 1 | (BX50E) |
|----|----------------------|---|---------|

SEMICONDUCTORS

| | | | |
|------|-----------------|---|---------|
| IC1 | 4093BE | 1 | (QW53H) |
| D1,2 | 1N4001 | 2 | (QL73Q) |
| LD1 | LED Red 5mm 2mA | 1 | (UK48C) |

MISCELLANEOUS

| | | | |
|-----|---------------------|-------|---------|
| PZ1 | Low Profile Sounder | 1 | (KU57M) |
| LR1 | LDR ORP12 | 1 | (HB10L) |
| | PP3 Clip | 1 | (HF28F) |
| | Pin 2145 | 1 Pkt | (FL24B) |
| | DIL Socket 14 Pin | 1 | (BL18U) |
| | PCB | 1 | (GH06G) |
| | ABS Box 2002 | 1 | (WY03D) |

| | | |
|----------------------|-------|---------|
| Poziscrew M3 × 10mm | 1 Pkt | (LR57M) |
| Steel Nut M3 | 1 Pkt | (JD61R) |
| Double Bubble Sachet | 1 | (FL45Y) |
| Instruction Leaflet | 1 | (XT41U) |
| Constructors' Guide | 1 | (XH79L) |

The Maplin 'Get-You-Working' service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LP50E (Peep Alarm Kit) Price £6.95.

Please note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following item (which is included in the kit) is also available separately, but is not shown in the 1992 Maplin catalogue.

Peep Alarm PCB Order As GH06G Price £2.25.

Sequential Logic continued from page 39.

Contrast this with (2) above where, out of the ten states it is low for FIVE and high for FIVE. In other words, the output (MSB) spends the same amount of time in both states, a long-winded way of saying the output has an equal mark/space ratio.

A straight binary divider will always produce a symmetrical output but counters of 'less than maximum' counts, such as the 7490 and 7492 will also produce symmetrical outputs if the divide-by-two element is placed last.

Previously in this series, the matter of up/down counters was discussed and the point made that, if the sequence at the Q outputs was looked at instead of that at the Q outputs, the complementary sequence would be seen. For a full binary divider of three stages, the Q outputs produce an UP sequence from 000 – 111, while the opposite sequence is seen at the Q outputs, namely 111 – 000. This allows the same counter to be used as either an up counter or a down counter merely by looking at the appropriate set of outputs. Does it work for all counters?

Consider the decade counter as an example.

The sequence at the Q outputs is: 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001.

This is clearly an UP sequence, in denary 0 – 9 inclusive.

The corresponding sequence at the Q outputs is:

1111, 1110, 1101, 1100, 1011, 1010, 1001, 1000, 0111, 0110.

This is clearly a DOWN sequence, but the wrong one! In denary, it is 15 – 6 inclusive.

It is obvious why we get this sequence when we compare the above up and down sequences. The binary values are all 4-bit numbers, so the complement of the lowest number in the sequence, namely 0000 is 1111, which is fine if we are making full use of all four bits. As we know, we are not, since the decade counter is a 'modulo-16' counter that has been 'chopped down' by skipping the highest six states. It is to our disadvantage

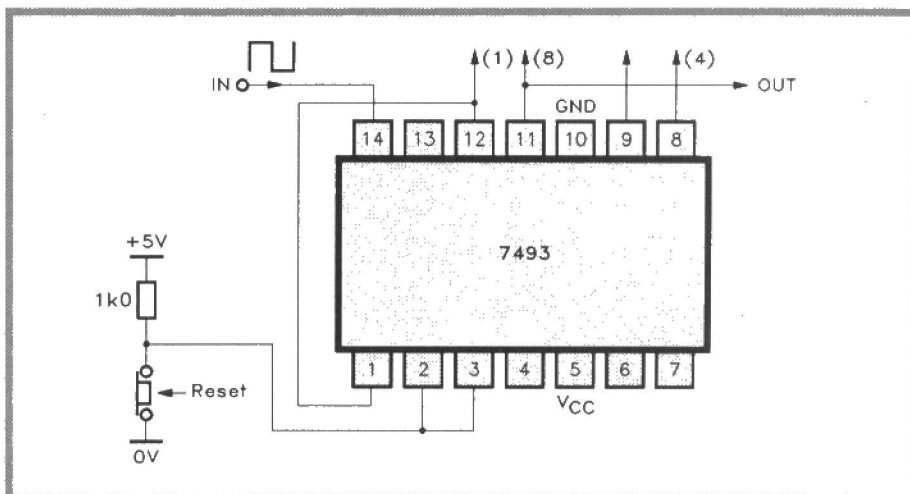


Figure 10. The 7493 modulo-16 pure binary counter with reset.

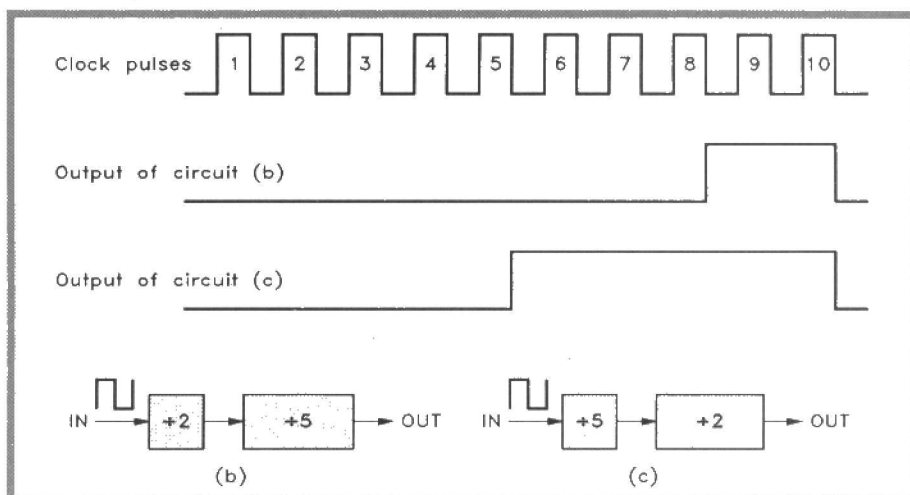


Figure 11. A symmetrical output obtained by reversing the order of the 7490's two internal sections. (a) Output waveforms against clock input (b) normal connection (c) reversed connection.

that the unwanted states all turn up as complements of the lowest six states in the required up sequence. This makes it useless as a down counter and we must look to other ways to achieve our aim. This subject will be discussed further later in the series.

Meanwhile, in the next part of this series we shall be looking at a powerful method for designing 'semi-discrete' synchronous counters to any base. If your Boolean algebra and ability to use Karnaugh maps are a bit rusty, now might be a good time for some revision!

MICRO-COMPUTER TESTING & FAULT FINDING

by Alan Pickard

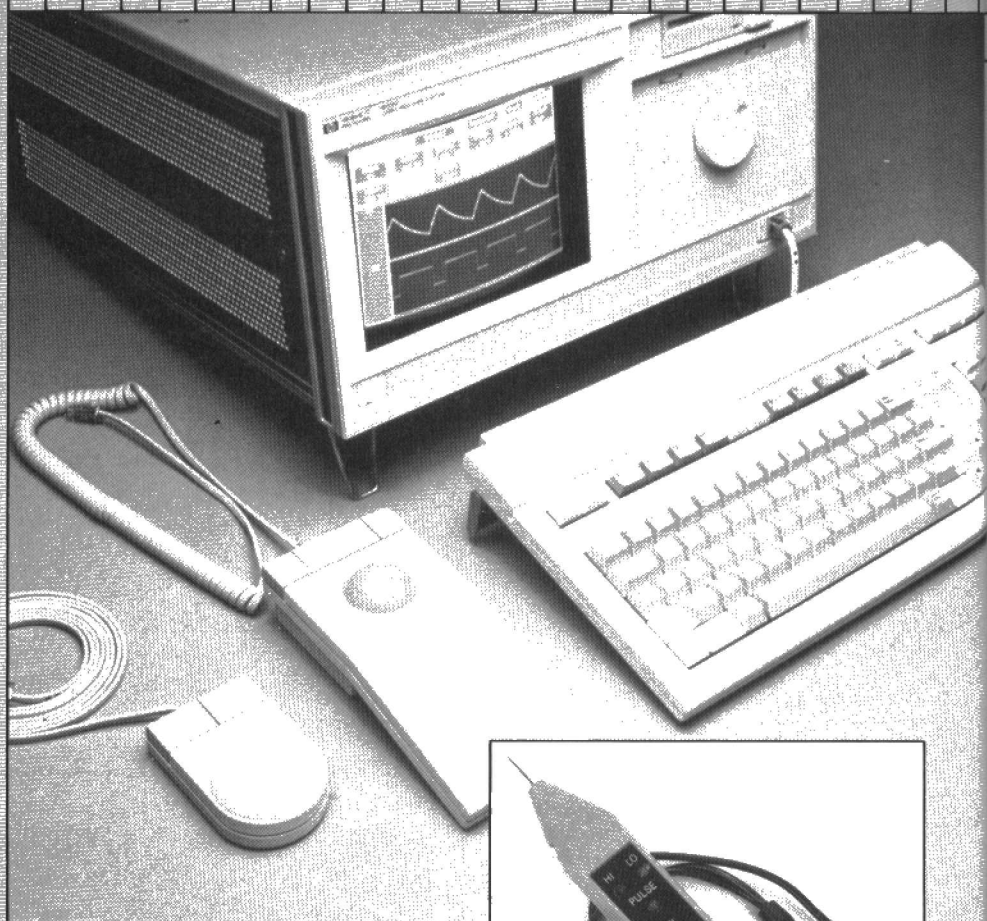
Part Four – Test Equipment

In the previous three parts of the series, we have looked at the basic hardware units of the microcomputer, including input/output devices. This part deals with the various types of test equipment used in microcomputer fault-finding. The oscilloscope (relevant to Parts 1 and 2) and floppy disc exerciser (Part 3) will be covered, and the frequency counter mentioned. The logic probe, pulser and analyser (the latter a very useful and specialised piece of test equipment), will be introduced. Finally, the signature analyser will be described.

The Oscilloscope

A golden rule with oscilloscopes is to satisfy yourself that it is set up and working correctly, before connecting it to equipment under test. Haphazard use of an oscilloscope can result in a great deal of time-wasting and frustration, which can be avoided by using a simple approach as follows:

It is unusual these days to find yourself operating anything other than a dual-trace oscilloscope, so the first thing to do is to make sure that you are using the correct channel – it is no use turning knobs and throwing switches for channel 2 if you



Top: The Hewlett-Packard HP16500A Logic Analyser System – an example of the current state-of-the-art. This unit can analyse up to 204 data channels, each with a data rate of up to 50 million bits per second. A colour touch-screen with pop-up menus ensures ease and quickness of set-up and use.

Centre: A Maplin Logic Probe.

Below: The Thurlby LA-160 Logic Analyser.



have the probe connected to channel 1! You may not be in a position to always use the same type (or make of oscilloscope), and therefore it is important to be able to work from basic principles when using an oscilloscope.

Most oscilloscopes have an internal oscillator, for calibration and checking purposes. This is usually a constant-frequency square-wave generator of a given amplitude. The 'CAL' output on the front panel usually states the amplitude of the signal, e.g. 300mV peak-to-peak. The frequency is not usually given (except in the operating manual) but this is not usually vital. By connecting the probe, of the channel to be used (e.g. channel 1) to this output (usually by just clipping it on), the timebase (common to both channels) and channel 1 amplitude controls can be set to produce a waveform centrally on the screen. This enables the user to then adjust the brightness and focusing of the trace. Just as importantly, it gives the user confidence that the oscilloscope and probe are working correctly. This internal oscillator can also be used for probe calibration, as will be seen later.

Having got this far, we will assume that the technician is able to re-adjust the timebase and amplitude controls as required, and does not need to turn knobs and press buttons indiscriminately when looking at test waveforms. It is very important to realise that if you cannot get to this stage there is no point in continuing further. In this case, the next step would be to get help from somebody else in setting up the oscilloscope.

Having a known working oscilloscope, we can now look at some waveforms. In Part 1 of the series we looked at a clock waveform signal, namely the Z80 MPU clock, a square-wave varying between 0V and 5V at a frequency of 4MHz. Connecting the oscilloscope probe to pin 6 (Ø) of the Z80 should produce such a waveform (refer to Part 1, Figure 1), with the amplitude and timebase controls adjusted as necessary. As this diagram indicates, the clock signal is not a perfect square-wave, and its rise and fall times for each edge are indicated. To measure amplitude or period (frequency) requires the calibration positions to be set for each control. It is very useful to be able to estimate (or calculate mentally) the expected result. Extracting frequency information from an oscilloscope trace can be confusing and misleading. Taking the simple example of a 1MHz clock rate, the period ($1/f$) would be $1/10^6 = 10^{-6} = 1\mu s$. Therefore, each half-cycle should be seen to be $0.5\mu s$ on the screen. This is a very useful exercise to try out with an oscilloscope.

Taking the Z80 4MHz waveform as another example, a 4MHz signal is four times as fast as a 1MHz one, and therefore its period will be a quarter of the time ($t = 1/f$). In this case, the period will be one quarter of a microsecond, i.e. 250ns (where 1 nanosecond = $1 \times 10^{-9}s$). Just as approximating or estimating answers (when using a calculator) provides sen-

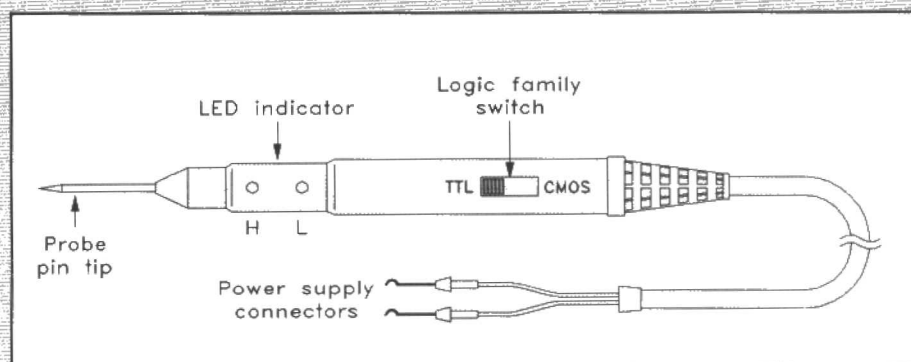


Figure 1. Logic Probe.

sible checking, knowing what to expect in terms of frequency and period is very useful.

With reference to Part 1, the 6502 clock waveforms (Ø1 and Ø2) on pins 3 and 39 can also be observed and measured (see Figure 13, Part 1). Opcode fetch machine cycles can also be observed (a simplified Z80 example is shown in Figure 12, Part 1).

Timing diagram waveforms, such as the Z80 opcode fetch machine cycle mentioned above, can be examined usefully with a two-channel oscilloscope, but up to 16 (or more) waveforms can be viewed simultaneously with the logic analyser covered later.

The video waveform (refer to Figure 12, Part 2) is another useful oscilloscope exercise, with the composite video signal having an amplitude of 1.0V, and one picture line having a period of $64.125\mu s$ (i.e. a frequency of 15.59kHz). Note that the picture signal component is 'positive-going', while the horizontal sync pulses are 'negative-going' with reference to +0.3V.

There is no substitute for practice when using an oscilloscope. A logical approach with the controls, and intelligent interpretation of timebase and amplitude settings become easier with experience. The examples given (and also the floppy disc testing waveform examples, Figures 8 (index-to-burst timing) and 11 ('cat's eyes' head alignment) from Part 3) will provide useful experience.

Oscilloscope Probes

Use of the oscilloscope probe is fairly straightforward, the only adjustments necessary being the switch on the probe

body for '×1' or '×10' operation. The multiplication factor refers to signal amplitude and if the ×10 switch is operative, it must be taken into account when interpreting the amplitude reading on the screen. Some probes do not have this switch and, unless marked otherwise, operate as ×1.

The other adjustment is via a screw slot in the body, which is actually a variable capacitor. This enables the probe to be 'calibrated' using the CAL output on the front panel of the oscilloscope (as previously described). The oscilloscope probe provides matching of the circuit under test and the oscilloscope input circuitry, whereas an ordinary coaxial cable would not, especially at high frequencies. At 10MHz, the capacitance of the scope input and the probe's lead could be over 100pF, equating to a reactance of around 160Ω at 10MHz! So that attenuation is equal across a wide frequency range, a trimmer capacitor is provided in the probe. This, in conjunction with the lead and input capacitances, forms a capacitive potential divider. When this trimmer is correctly adjusted, an overall attenuation of 10:1 will be applied across the frequency range. Calibration is achieved using the oscilloscope 'CAL' output; the trimmer is simply adjusted so that the square-wave trace appears 'square' i.e. the leading edges of the waveform are not rounded or 'spiky'.

The Frequency Counter

Although the frequency counter is not often used in microcomputer testing and fault-finding, it can be a useful method of verifying a frequency which has been 'calculated' using an oscilloscope. Obviously the counter used will need to be able to cope with frequencies in excess of 4MHz, when looking at MPU signals. Most counters enable frequency or period to be displayed, and some oscilloscopes have a built-in counter. Oscilloscopes, by their basic flexibility, provide the most convenient means of measuring amplitude, period (and indirectly, frequency), as well as providing the essential pictorial information.

The Logic Probe

The logic probe, shown in Figure 1, is an easy-to-use test instrument, which investi-

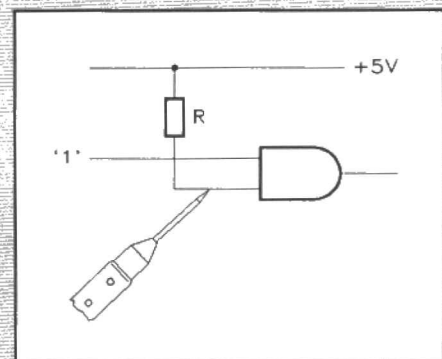


Figure 2. Using a logic pulser to test an AND gate.

DISPLAY

| Cursor Count | HEXADECIMAL | | BINARY | |
|--------------|------------------|------------------|---------------------|-----------|
| | Address | Data | Address | Data |
| -07 | Random | Random | Random | Random |
| -05 | Random | Random | Random | Random |
| -04 | 0030 | A9 | 0000 0000 0011 0000 | 1010 1001 |
| -03 | 0031 | AA | 0000 0000 0011 0001 | 1010 1010 |
| -02 | 0032 | 8D | 0000 0000 0011 0010 | 1000 1101 |
| -01 | 0033 | 1B | 0000 0000 0011 0011 | 0001 1011 |
| Trigger word | 0034 | 02 | 0000 0000 0011 0100 | 0000 0010 |
| +01 | 021B | AA | 0000 0010 0001 1011 | 1010 1010 |
| +02 | 0035 | A9 | 0000 0000 0011 0101 | 1010 1001 |
| +03 | 0036 | FF | 0000 0000 0011 0110 | 1111 1111 |
| +04 | 0037 | 8D | 0000 0000 0011 0111 | 1000 1101 |
| +05 | 0038 | 1C | 0000 0000 0011 1000 | 0001 1100 |
| +06 | 0039 | 02 | 0000 0000 0011 1001 | 0000 0010 |
| +07 | 021C | FF | 0000 0010 0001 1100 | 1111 1111 |
| +08 | 003A | 00 | 0000 0000 0011 1010 | 0000 0000 |
| +09 | Break subroutine | Break subroutine | | |

Figure 3. Address, data and cursor information.

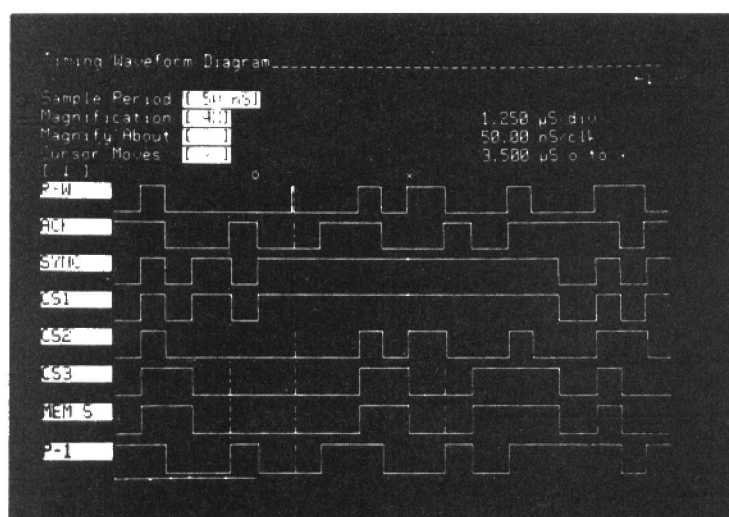


Figure 4. Logic analyser timing display.

gates the logic state of any node in a digital circuit. (A node is an interconnection between two or more logic devices). A logic probe can indicate the presence of logic '1', logic '0' or an open circuit. This indication is via illumination of an LED. Unlike an oscilloscope or multimeter, it provides only two-state 'on' or 'off' indication, i.e. digital information. Many logic probes also show open circuits ('floating inputs') and pulse trains ('pulsing' operation). Several up-market probes also feature a 'pulse memory', so that pulses of very short duration can be detected. This feature is also very useful if the technicians eyes need to be elsewhere!

The logic probe derives its power from the circuit under test via probe clips or crocodile clips connected to +5V and 0V. The probe can usually be switched for TTL or CMOS operation.

For TTL operation, if a DC voltage is detected between 0 and 0.8V, this registers as logic '0'. If the input voltage from the probe is between 2.4 and 5V, then logic '1' is displayed, where V_{CC} (the supply voltage) is +5V. Voltages between 0.8V and 2V are 'indeterminate'.

For CMOS operation, logic 1 is $0.7 \times V_{DD}$ (where V_{DD} is in the range 3 to 15V), while logic 0 = $0.3 \times V_{DD}$ ($0.3 \times V_{DD}$ to $0.7 \times V_{DD}$ is indeterminate).

The subscript 'cc' is derived from 'collector' (TTL i.e. bipolar) and 'dd' from 'drain' (CMOS i.e. FET).

Logic Pulser

The logic probe is very useful where quick inspection of nodes, and the presence of 1's or 0's, are of interest. The logic pulser, also helpful, is less common than a probe, but can be used in conjunction with one for some fault finding.

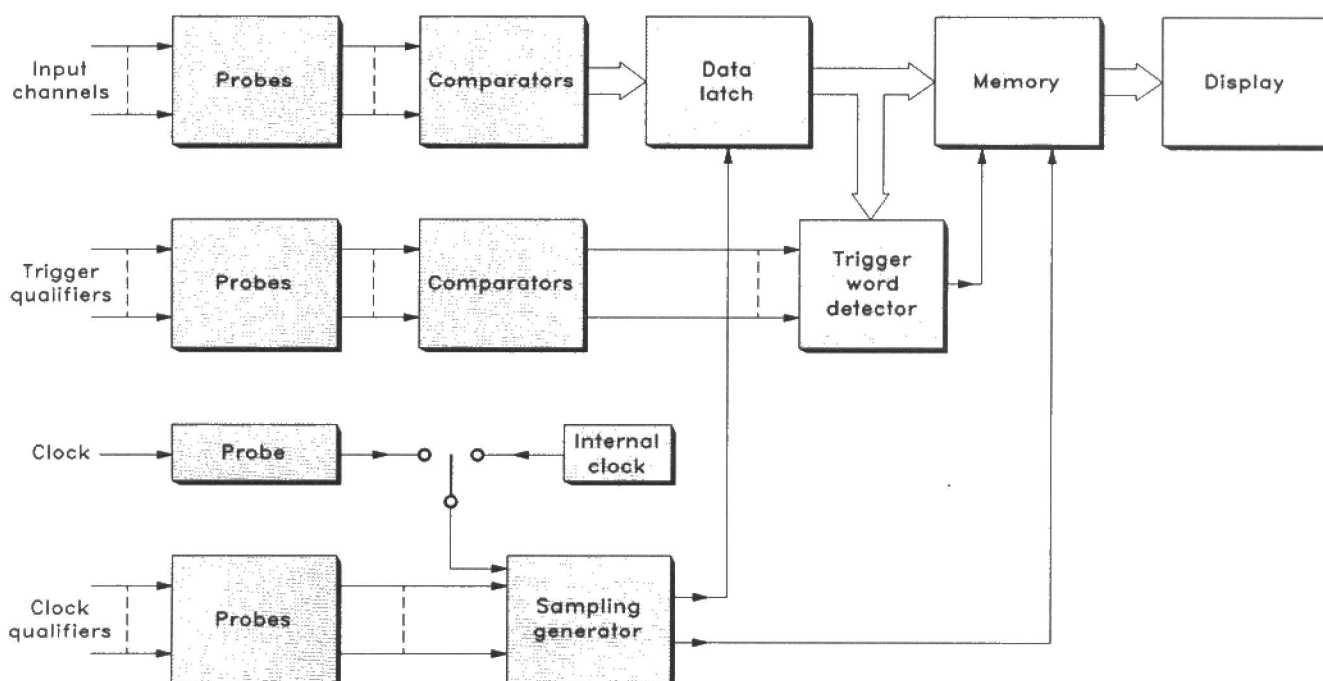


Figure 5. Block diagram of logic analyser.

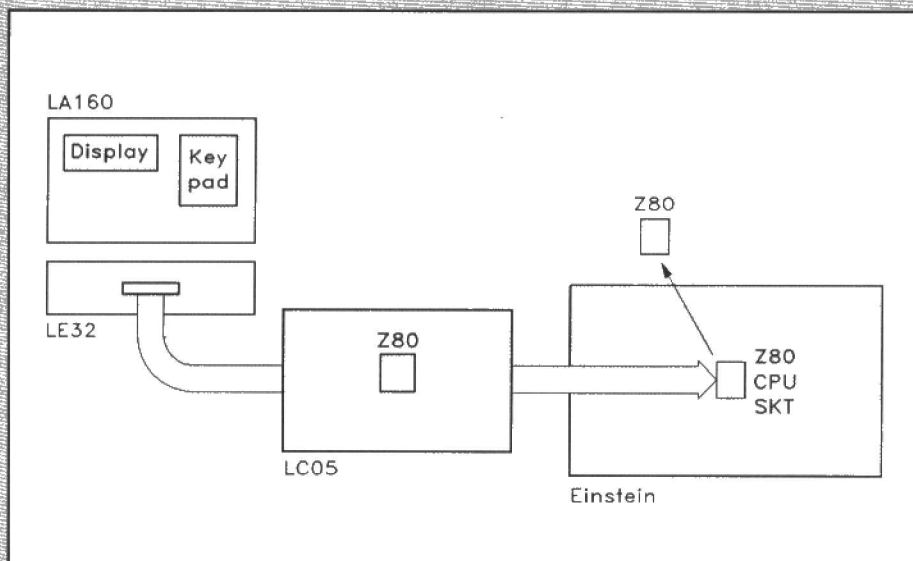


Figure 6. Connection of Thurlby LA-160 to Einstein computer via Z80 Personality Module.

The pulser is designed to force a single node to change its logic level for a short period. In other words, a short duration pulse is injected into a circuit under test to stimulate activity. The duration of the pulse is typically $1.5\mu\text{s}$ for TTL, and $10\mu\text{s}$ for CMOS.

When the logic pulser is connected to the circuit under test, and the appropriate node is touched by the pulser tip, the existing logic level is detected, and a pulse of the opposite level is then 'injected' automatically.

Pressing the 'pulse' button once, injects a bounce-free single pulse. As the pulser takes its power supply from the unit under test, voltage levels are also adjusted automatically. If the 'pulse' button is held depressed, it will produce a stream of pulses at the pulser tip of about 100Hz. An example of pulser operation is shown in Figure 2. In this example, the pulser is used to drive the input of an AND gate from the normal '1' level (due to pull-up resistor R), to the '0' level, for $1.5\mu\text{s}$. If the gate is functioning correctly, then this pulse can be detected at the output. Pulses injected like this can be traced through subsequent stages. Pulsers may also be used to clock sequential circuits, such as clocked bistables, counters and shift registers.

Care should be taken when using logic pulsers in circuits with VLSI components, to ensure that excessive currents are not forced onto the terminals of these devices.

The Floppy Disc Exerciser

Because the floppy disc exerciser was covered in detail in the previous issue (Part 3 of the series, 'Floppy disc and hard disc drives'), and was an integral part of the article, its operation will not be duplicated here. A floppy disc exerciser, although specialised, is not difficult to use and has probably more educational value than practical use, due to the reliability of the disc drive mechanisms in common usage.

Logic Analyser

This is a piece of specialised test equipment used for observing digital waveforms in a microcomputer or microprocessor-based system. It is specially designed to be able to examine information present on, for example, the address bus of a microprocessor, consisting of typically 16 lines, or wires (i.e. a 16-bit address bus).

A logic analyser is similar to an oscilloscope in many ways. It has signal inputs, a trigger, timing circuitry and usually a cathode ray tube display. There are, however, low-cost and portable analysers, which present their output information on a multi-digit seven-segment display. Figure 5 shows the block diagram of a complete logic analyser.

A logic analyser may be considered to be an oscilloscope with 16 digital channels, having a 16-channel probe set or pod, which enables connection directly to an address or data bus (or both), and by means of a 40-pin test clip may be connected directly to a MPU.

In practice terms, this equipment can be used to examine waveforms (timing diagrams), logic states (binary or hex) and also map displays in a microprocessor based system. Testing is carried out on a working program, whether it is part of the machine operating system or a user program. A suitable test program to illustrate the operation of the analyser is:

```
0100 LD A, OFFH
0102 LD (0200H),A
0105 INC A
0106 RST 38H
```

In other words, this program can enable the analyser to be used to examine the operation of a program in a microprocessor-based system.

Continued on page 78.

Z80 DISASSEMBLER

| LOC | ADDR | CODE (DATA) | MNEMONIC |
|-----|------------|-------------|---------------|
| 000 | 0100 | 3E FF | LD A, FFFH |
| 007 | 0102 | 32 00 02 | LD (0200H), A |
| 017 | 0200-WRITE | FF | |
| 020 | 0105 | 3C | INC A |
| 024 | 0106 | FF | RST F38H |
| 029 | 00FF-WRITE | 01 | |
| 032 | 00FE-WRITE | 07 | |
| 035 | 0038 | | |

Figure 7. Thurlby logic analyser disassembled listing.

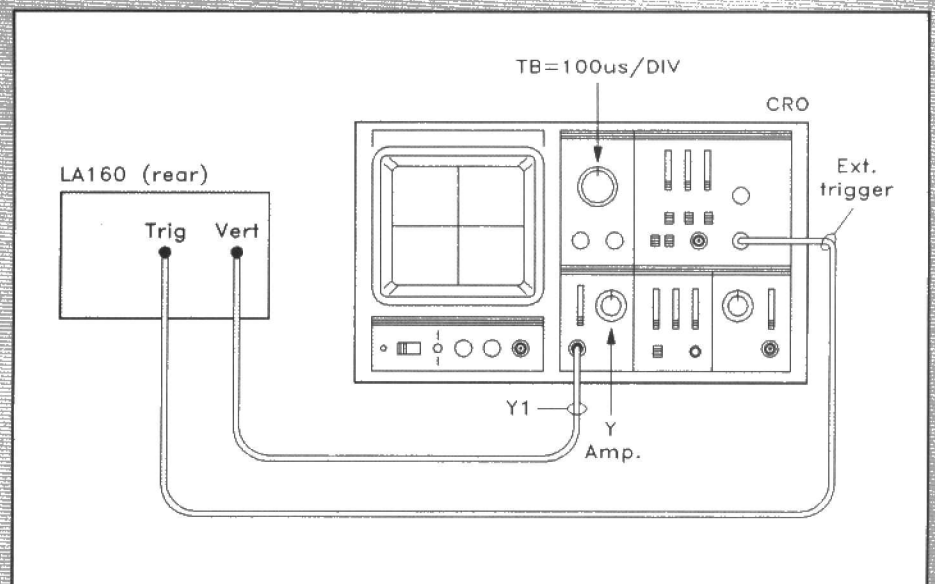
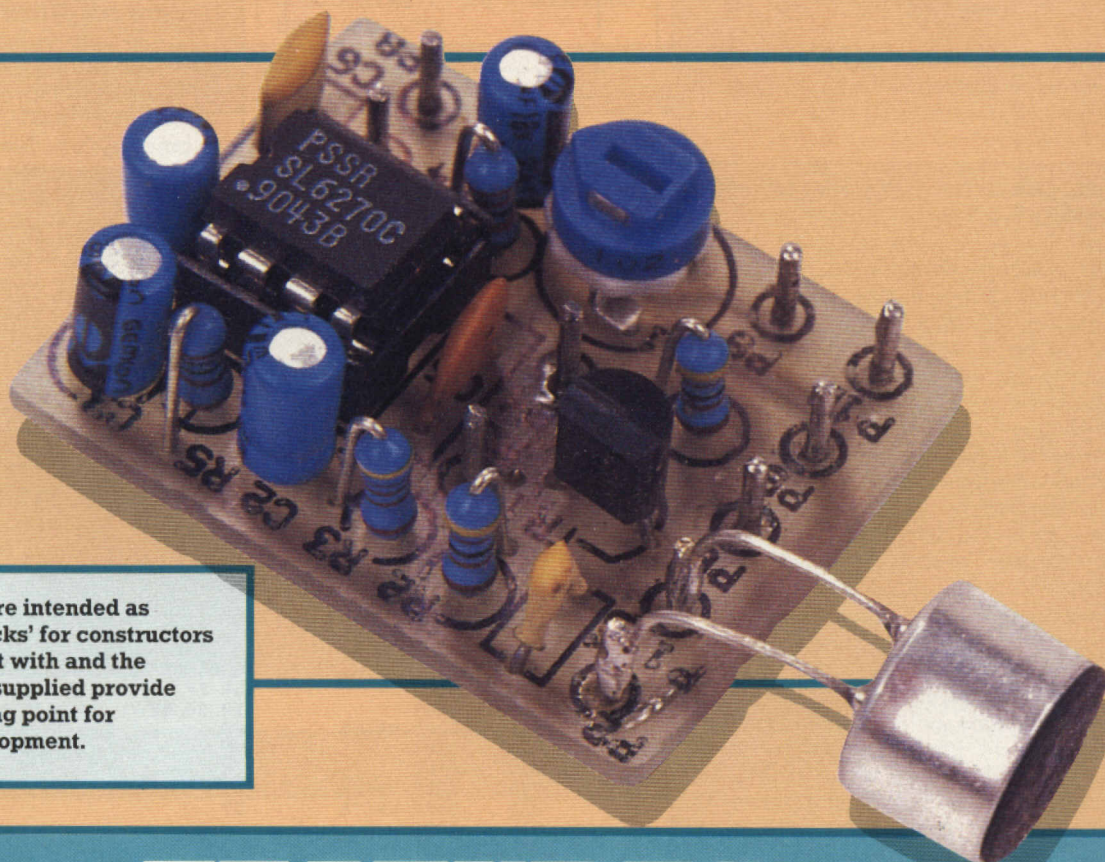


Figure 8. Connection of oscilloscope to LA-160 to produce a timing diagram display.



SL6270

AGC MICROPHONE PREAMPLIFIER



'Data Files' are intended as 'building blocks' for constructors to experiment with and the components supplied provide a good starting point for further development.

FEATURES

- ★ **CONSTANT OUTPUT SIGNAL**
- ★ **FAST ATTACK**
- ★ **LOW POWER CONSUMPTION**
- ★ **SIMPLE CIRCUITRY**
- ★ **SINGLE-ENDED OR DIFFERENTIAL INPUT**

APPLICATIONS

- ★ **Audio AGC system**
- ★ **Transmitter overmodulation protection**
- ★ **Tape recorders**
- ★ **Audio surveillance**

The SL6270 is a small 8-pin Integrated Circuit (IC) combining the functions of an audio amplifier and Voice Operated Gain Adjusting Device (VOGAD). It is designed to accept small signals from a microphone and to provide an essentially constant output signal from an

input covering a range of 50dB. The dynamic range, attack and decay times are controlled by external components. The device will operate over a wide range of power supply voltages between 4.5V to 10V and consumes only 9mA from a 9V battery. Figure 1 shows the IC

pinout, and Table 1 gives the electrical characteristics of the device.

IC Description

Figure 2 shows the block diagram of the SL6270. Its positive power supply input is on pin 3, which should be decoupled to 0V ground by a

small 100nF ceramic capacitor. Pin 6 is used as a common 0V ground return for all stages within the device.

The AGC controlled preamplifier stage has a true differential input on pins 4 and 5, allowing it to be driven single endedly without the problems caused by other

forms of push-pull circuits. The applied audio signal must be AC coupled to the input via a capacitor, and in the single ended mode it can be applied to either input. Each input has a very low impedance, only 150Ω if single-ended, doubling up to 300Ω if differential mode is used. Signals of less than a few hundred microvolts are amplified normally, but as the input level increases the AGC begins to take effect and the output signal on pin 8 is held constant at approximately 90mV rms over the full input range of 50dB, see Figure 3. The test conditions used to obtain this graph were as follows: power supply voltage +6V, input frequency 1kHz, ambient temperature +25°C, single-ended input. In order to ensure that internal offsets within the amplifier are of such polarity as to inhibit oscillation at the onset of AGC, a 22k

PROTOTYPE SPECIFICATION

| | |
|-----------------------------|---|
| Power Supply Voltage: | +4.5V to +10V (P6) and 0V (P5) |
| Power Supply Current: | 11mA (+9V Supply) |
| Microphone Input: | Electret or Dynamic inserts |
| Input Impedance: | Electret 4k7Ω (P1) and 0V (P2) Dynamic 150Ω (P3) and 0V (P2) Dynamic 300Ω (P3 and P4) |
| Voltage Gain: | 52dB |
| Maximum Output: | 90mV rms (P9) and 0V (P10) |
| Minimum Load Impedance: | 1kΩ |
| Frequency Bandwidth (−3dB): | 300Hz to 3kHz |

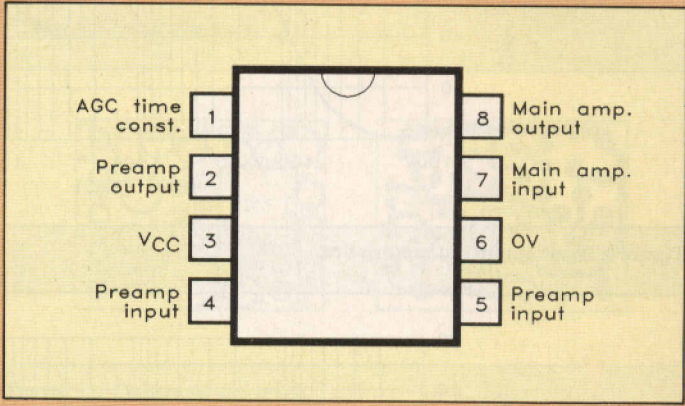


Figure 1. IC Pin connections.

extends beyond 1MHz, see Figure 4. However, this bandwidth can be restricted by placing an external capacitor between pins 7 and 8. These are the input and output connections of the main amplifier, which has an internal 10kΩ resistor to set the flat response open loop gain. As the value of the external capacitor increases, the upper frequency response decreases and for radio communications this is normally chosen to give a −3dB point at 3kHz, which corresponds to 4.7nF. In addition, the dynamic range and sensitivity of the system can be reduced by placing a resistor between these two pins, and as its value decreases, the voltage gain of the main amplifier will continue to drop. An approximate reduction of 20dB in gain can be achieved with a

| Test conditions – Supply voltage V_{CC} : 6V Input signal frequency: 1kHz Ambient temperature: −30°C to +85°C | | | | | |
|---|-------|------|------|--------|---------------------------------------|
| Characteristic | Value | | | Units | Conditions |
| | Min. | Typ. | Max. | | |
| Supply current | | 5 | 10 | mA | |
| Input impedance | | 150 | | Ω | Pin 4 or 5 |
| Differential input impedance | | 300 | | Ω | |
| Voltage gain | 40 | 52 | | dB | 72μV rms input pin 4 |
| Output level | 55 | 90 | 140 | mV rms | 4mV rms input pin 4 |
| THD | | 2 | 5 | % | 90mV rms input pin 4 |
| Equivalent noise input voltage | | 1 | | μV | 300Ω source, 400Hz to 25kHz bandwidth |

Table 1. Typical electrical characteristics.

resistor should be connected from pin 5 to the 0V supply line. The output from the AGC preamp stage (pin 2) is coupled via a capacitor to the input of the main amplifier (pin 7). The low frequency (LF) response of the system is determined by the value of this capacitor and the internal 680Ω resistor on pin 2. For normal speech radio communications, this coupling capacitor is chosen to give a −3dB output amplitude point at 300Hz, which corresponds to 2.2μF. The LF response can be extended down to 100Hz or less by simply increasing the value of this capacitor, although values greater than 100μF are not recommended. The combined amplification system has an upper frequency response which

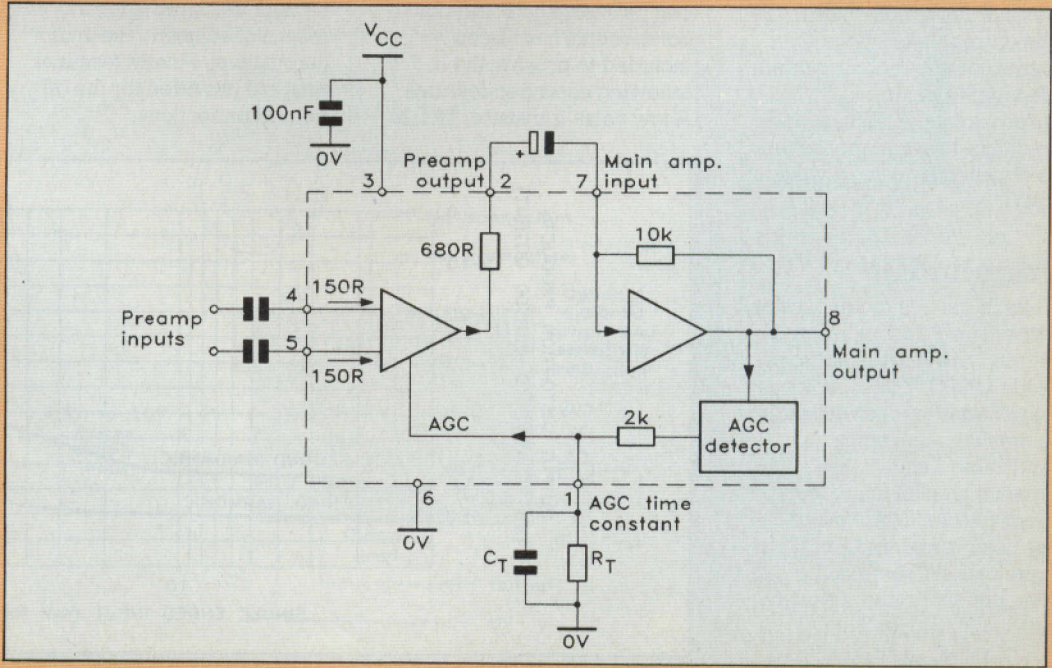


Figure 2. Block diagram.

value of $1k\Omega$, but values less than 680Ω are not advised. The final audio output on pin 8 has a small DC offset voltage, so it is good practice to use an AC coupling capacitor before connecting it to any other circuits. To ensure a good LF response into loads as low as $1k\Omega$, this capacitor should be not less than $22\mu F$.

The main amplifier also drives the AGC detector, and the DC voltage generated by this circuit is directly related to the signal level applied to the preamp input pins 4 and 5. This control voltage is used to progressively reduce the gain of the preamp as the input level increases. Because of its careful design, the device has an extremely high input dynamic range and using the same test conditions as before; Figure 5 shows the distortion characteristics at various input levels.

The AGC attack and decay characteristics are set by the external RC timing components on pin 1. Normally the SL6270 is required to respond quickly by holding the output level almost constant as the input level is increased. This attack time is set by the value of the capacitor C4, and is defined as the time taken for the output to return to within 10% of the original level following a 20dB increase in input level. A fast attack response can be obtained by using an electrolytic capacitor in the range $22\mu F$ to $47\mu F$. The decay time is set by the value of the resistor R6, which discharges the current held by the capacitor, the recommended decay rate being approximately 20dB/second, and this slower response time is obtained by using a value of $1M\Omega$.

Maplin Kit

A kit of parts, including a small fibreglass PCB with printed legend, is available as stock code LP98G. The basic kit as supplied is for use with radio communication equipment, and Table 2 shows the specification of the prototype. Because the SL6270 may be used in many varied applications, some of the component values supplied in the basic kit will not be suitable, so alternative values must be calculated to

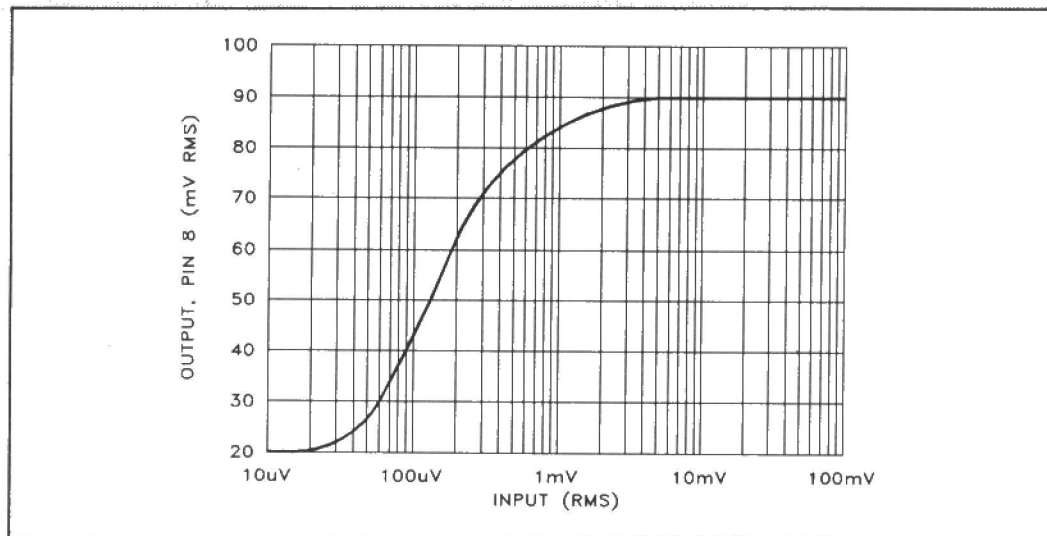


Figure 3. Input/output characteristics.

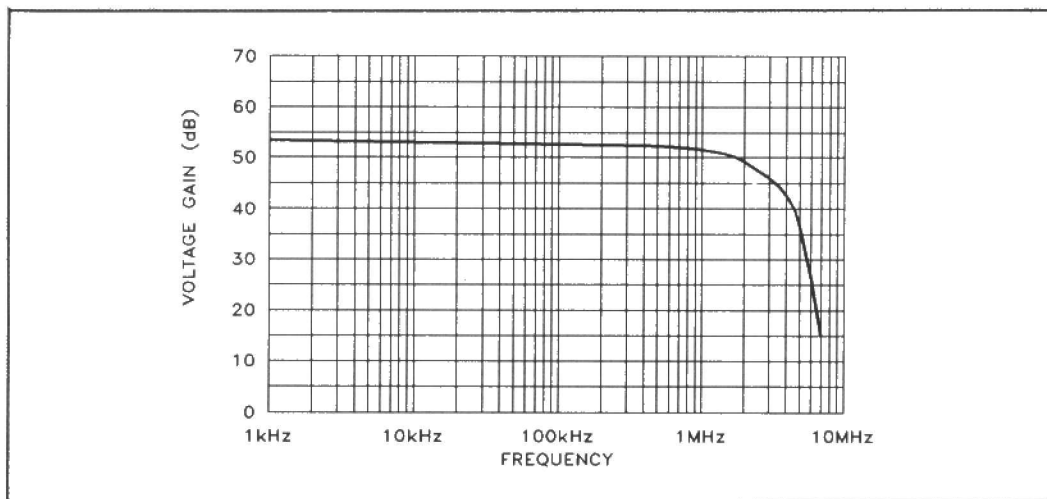


Figure 4. Frequency response.

determine the new working parameters.

Figure 6 shows the circuit diagram of the module, and as can be seen, some additional components have been included to provide the following extended features. A low noise transistor, TR1, is

used to provide a suitable input for an electret microphone insert which is included in the kit. A preset resistor, RV1, provides the means of adjusting the audio output level. Finally, terminal pins are provided for the off-board connections:

- P1. Electret microphone insert signal input.
- P2. Electret microphone insert 0V ground.
- P3. Dynamic microphone insert signal input 1.
- P4. Dynamic microphone insert signal input 2.

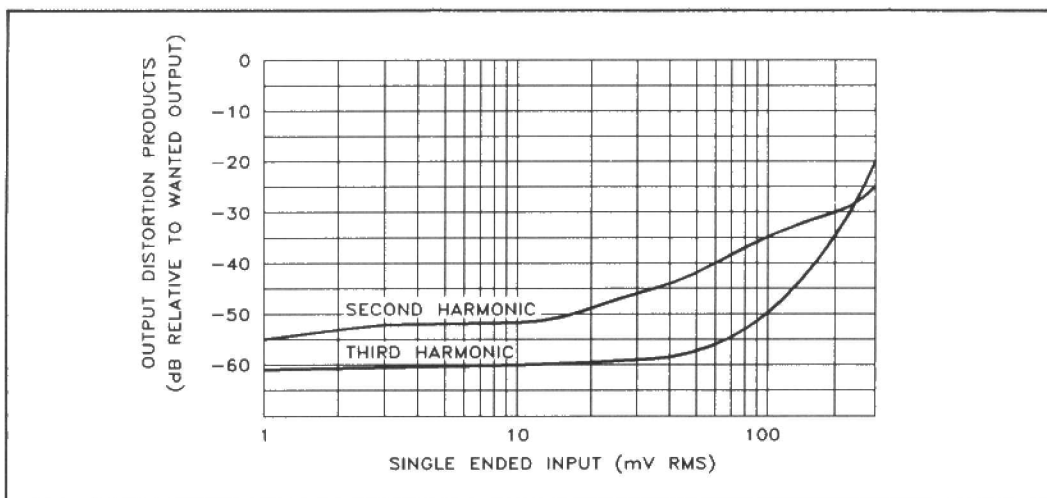


Figure 5. Distortion products versus input signal.

- P5. 0V ground power supply (-V battery).
- P6. +V power supply input (+4.5V to +10V).
- P7, P8. Dynamic range and sensitivity reduction (4k7 or 1k resistor).
- P9. Audio output (90mV rms into 1k).
- P10. Audio output 0V ground.

All the components and their relative positions are shown in Figure 7.

Using the Module

The electret microphone insert connections to the module are illustrated in Figure 8a. This wiring diagram also shows the power supply, audio output and optional dynamic insert (not supplied in kit) then the option outlined in Figure 8b (single-ended), or 8c (differential) should be followed, taking note of the necessary component changes to the PCB:

Remove R1, R2, R3, C1 and TR1.

Reverse the polarity of C2.

To minimise any stray electrical noise pick-up, the connecting leads between the microphone insert and the module should be kept as short as possible, e.g. less than 50mm. For longer runs screened cable is recommended (as supplied in kit) but this too should be kept as short as possible, e.g. less than 500mm. When using electret or dynamic single-ended inserts, miniature single core screened cable is suitable. However, when using a dynamic microphone in the differential input mode, as in Figure 8c, open wires or twin overall screened cable can be used. To ensure effective screening, the outer braiding of the cable should *always* be connected to the 0V ground on P2.

The module is designed to operate over a wide supply voltage range and has a relatively low power consumption, making it suitable for battery operation. A good quality alkaline 9V PP3 battery is capable of running the circuit for a considerable period of time. For this reason a PP3 battery clip is also included in the kit. However,

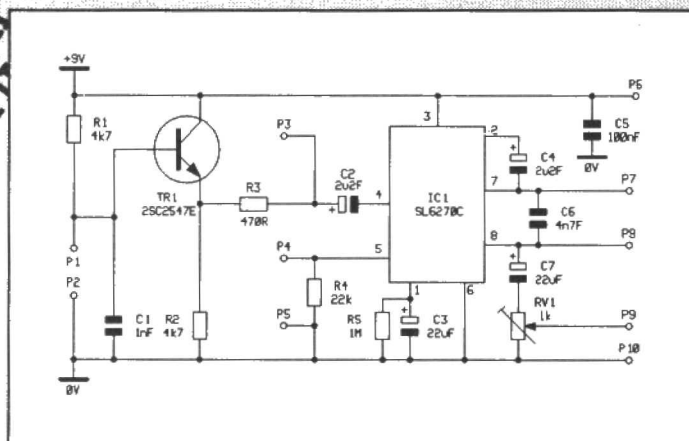


Figure 6. Circuit diagram.

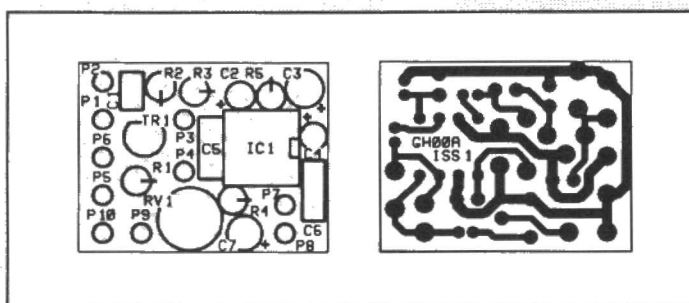
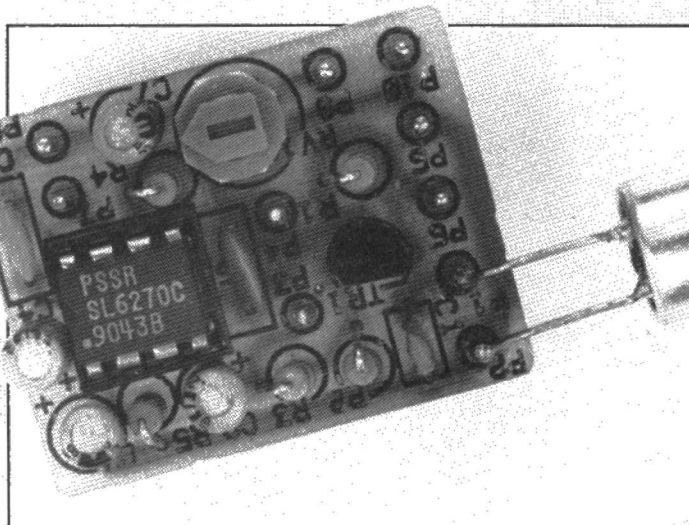


Figure 7. PCB legend and track.



Close-up of assembled PCB.

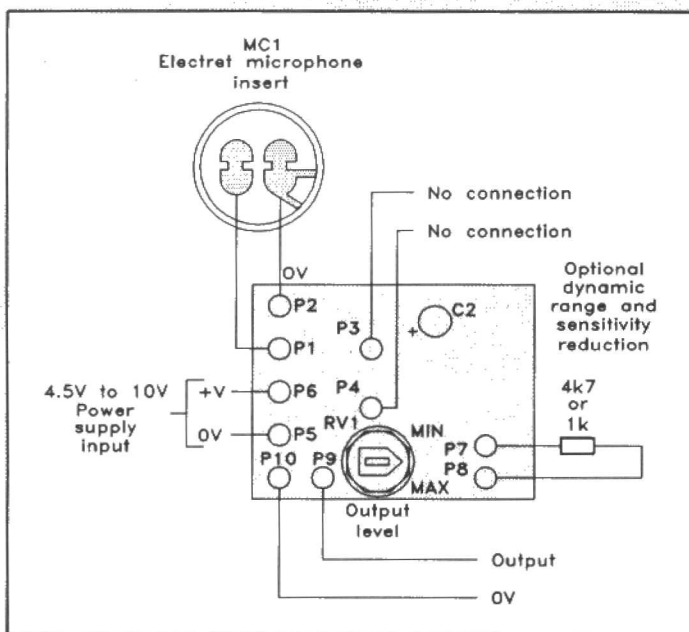


Figure 8a. Wiring diagram A.

no on/off switch is supplied because of the numerous switching styles, types and methods available, here are just a few to choose from:

Toggle, Rocker, Rotary, Slide, Push and microphone PTT.

On most radio communication microphones an integral Push-To-Talk (PTT) switch is used to activate the transmitter. If this switch has a spare set of contacts then the power to the module can only be applied during the transmit period, so this technique extends the operational life of the battery. If you do not intend to use a battery then it is important that the power supply is adequately decoupled to prevent audio, digital, or mains derived hum and noise from entering the circuit via the supply rail.

Screened cable should also be used on the audio output of the module and be kept as short as possible, e.g. less than 3 metres. To ensure effective screening the outer braiding of the cable must be connected to the 0V ground at P10. The output level of the module is adjusted by RV1, with its minimum setting at the fully counterclockwise position, see Figure 8.

With no additional resistor placed across pins P7 and P8 the sensitivity of the module will be at maximum. Under this condition any low level sound picked up by the microphone will be highly amplified. If there is an unduly high level of distracting background noise the overall speech intelligibility will suffer. To minimise this effect the sensitivity of the module must be reduced by adding a resistor across P7 and P8, see Figure 8. As its value decreases, so also will the sensitivity, until the permitted 680Ω minimum is reached. After some experimentation the following resistor values where chosen:

No resistor = full sensitivity.

4k7 resistor = medium sensitivity.

1k resistor = low sensitivity.

As the sensitivity decreases it will become necessary to speak louder, and/or closer to the microphone in order to maintain the same average output level.

AGC MICROPHONE PREAMPLIFIER PARTS LIST

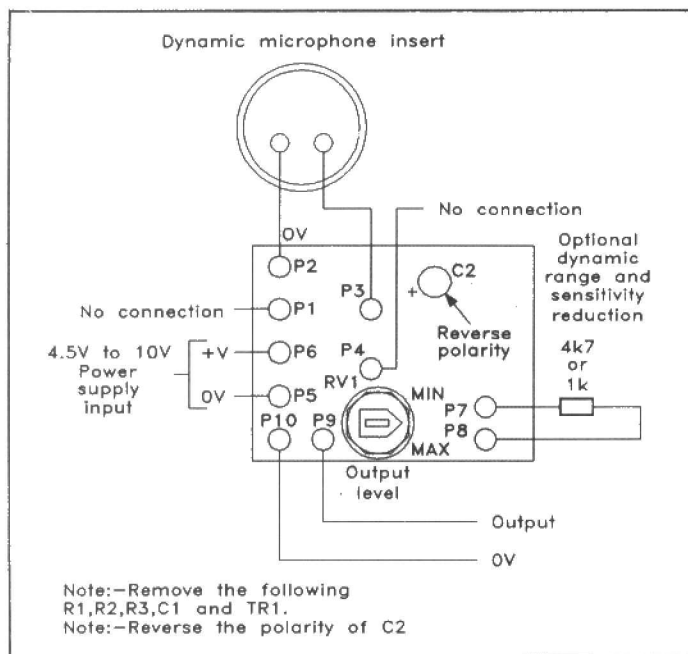


Figure 8b. Wiring diagram B.

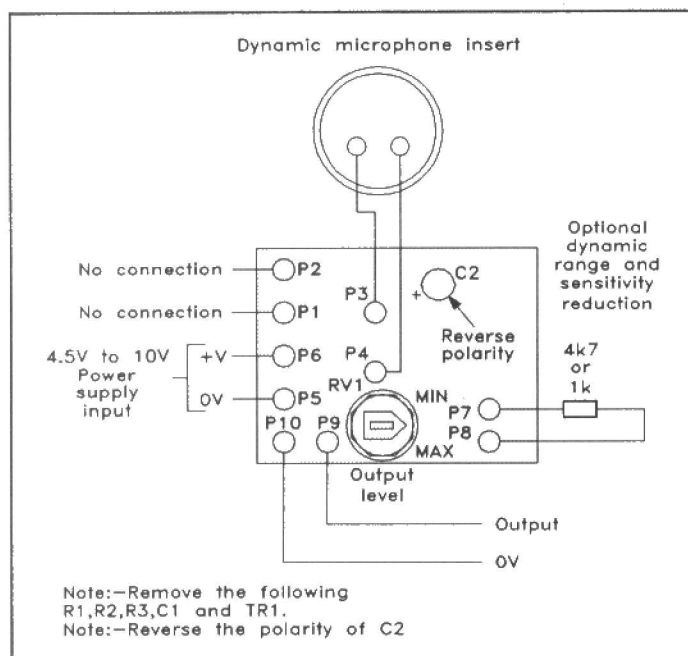


Figure 8c. Wiring diagram C.

RESISTORS: All 0.6W 1% Metal Film (Unless specified)

| | | | |
|------|-----------|---|---------|
| R1,2 | 4k7 | 2 | (M4K7) |
| R3 | 470Ω | 1 | (M470R) |
| R4 | 22k | 1 | (M22K) |
| R5 | 1M | 1 | (M1M) |
| RV1 | Cermet 1k | 1 | (WR40T) |
| | 4k7 | 1 | (M4K7) |
| | 1k | 1 | (M1K) |

CAPACITORS

| | | | |
|------|--------------------|---|---------|
| C1 | Ceramic 1nF | 1 | (WX68Y) |
| C2,4 | Minelect 2μF 63V | 2 | (YY32K) |
| C3,7 | Minelect 22μF 16V | 2 | (YY36P) |
| C5 | Minidisc 100nF 16V | 1 | (YR75S) |
| C6 | Ceramic 4n7F | 1 | (WX76H) |

SEMICONDUCTORS

| | | | |
|-----|----------|---|---------|
| IC1 | SL6270C | 1 | (UL87U) |
| TR1 | 2SC2547E | 1 | (QY11M) |

MISCELLANEOUS

| | | | |
|-------|--------------------------|---------|---------|
| P1-10 | Pin 2145 | 1 Pkt | (FL24B) |
| | DIL Socket 8-pin | 1 | (BL17T) |
| | PCB | 1 | (GH00A) |
| | Quickstick Pads | 1 Strip | (HB22Y) |
| | PP3 Clip | 1 | (HF28F) |
| | Min Screened Cable | 1m | (XR15R) |
| | Submin. Omni Mic. Insert | 1 | (FS43W) |
| | Instruction Leaflet | 1 | (XT26D) |
| | Constructors' Guide | 1 | (XH79L) |

OPTIONAL (Not in Kit)

| | | |
|----------------------|---|---------|
| Alkaline PP3 Battery | 1 | (FK67K) |
|----------------------|---|---------|

The Maplin 'Get-You-Working' Service is not available for this project.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LP98G (SL6270 AGC Mic Amp) Price £7.45.

Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not to be found in the 1992 Maplin catalogue.

AGC Preamp PCB Order As GH00A Price £1.95.



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PART SEVEN The Rectifier Circuit

by Philip Lawton

PREDICTING WAVESHAPES USING A COMPUTER

In the last part of this series, I will explain how to predict the transient and steady-state waveshapes that appear in rectifier circuits. The rectifier circuit shown in Figure 24 is used to illustrate how to apply the fundamental laws in order to obtain, respectively, a non-linear equation and a 'rate' equation. This is followed by the description of a computer program used to evaluate these equations for any applied input emf, and to plot the predicted waveshapes. The input used is a sine wave at a frequency of 50 Hertz ($100 \sin 314t$).

Finally, the predicted waveshapes are discussed and a number of 'Things to do' are suggested.

Fundamental Laws

A rectifying device is one which permits current (charge) to flow in one direction only. The diode shown in Figure 24 is such a device (see also the first chapter of Reference 1). Associated with the diode, d , is a barrier potential of 0.6 volts, together with a resistor, r_d , representing the internal resistance of the diode, and hence the fact that it gets hot. The diode has a low impedance when $e > (d + v)$, during which the current is positive and predicted by $(e - d - v)/(r_s + r_d)$.

A useful law for the capacitor relates the current (i) to the product of the capacitance (C), and the 'rate of change', with respect to time, of the potential difference of the capacitor (sv).

The law is $i = C \cdot sv$
(derived from $q = C \cdot v$)

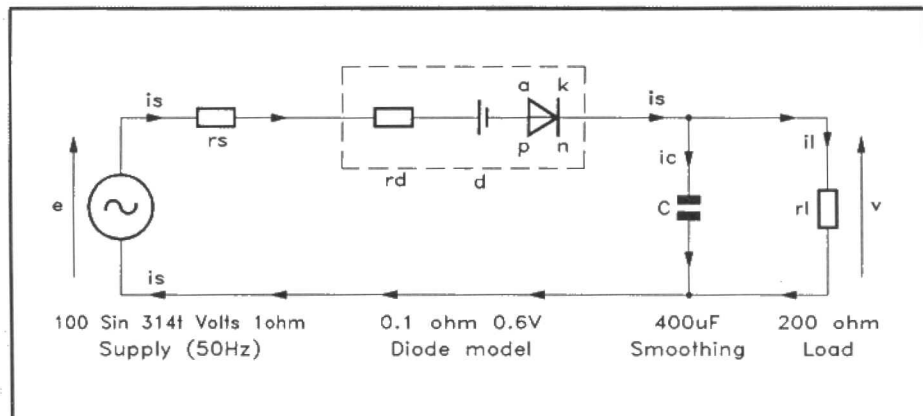


Figure 24. Rectifier circuit, half-wave or 'one-pulse'.

This law predicts the fact that when a current exists then the potential difference of the capacitor will change.

Equations

Equations to model the rectifier circuit can be derived using Ohm's law, Kirchhoff's current law, and the above capacitor law. Note that the waveshape of the applied input signal is represented by the symbol e (volts), and that the resultant effects are current values (amps) and a capacitor potential v (volts).

These equations are:

$$i_s = (e - d - v)/(r_s + r_d)$$

Ohm's law, positive current only (diode);

$$i_l = v/r_l$$

Ohm's law;

$$i_c = i_s - i_l$$

KCL;

$$sv = i_c/C$$

Capacitor law;

where:

i_s is the supply current,

e is the applied emf,

d is the diode barrier potential,

v is the capacitor potential,

r_s is the supply resistance,

r_d is the diode resistance,

i_l is the load current,

r_l is the load resistance,

i_c is the capacitor current,

sv the rate of change of the capacitor potential,

C is the value of the capacitor.

These equations can be used to evaluate the rate of change with respect to time of the output voltage and hence the change.


```

10 REM REC Listing 1 PC version
20 REM Rectifier 1 pulse or 2 pulse
30 REM Evaluate voltage and current
40 V=0 : H=.000056 : SCREEN 2 : CLS
50 RS=1 : RD=.1 : D=.6 : C=.0004 : RL=200
90 FOR T=0 TO 3*.02 STEP H : X=T*10000
100 LET E=100*SIN(314*T+0) : REM 1 pulse
105 E=E*SGN(E) : REM 2 pulse
110 PSET(X,100) : REM zero line
120 PSET(X,100-E*.5) : REM in volts
130 PSET(X,100-V*.5) : REM out volts
140 IS=(E-D-V)/(RS+RD) : IF IS<0 THEN IS=0
145 IL=V/RL : IC=IS-IL : SV=IC/C : REM rate
150 PSET(X,100-IS*5) : REM in amps
155 PSET(X,100-IL*5) : REM out amps
160 REM At time T+H secs : -
170 LET V=V+SV*H : REM integrate
180 NEXT T : REM describe

```

Listing 13. The prediction program in PC GW BASIC.

```

10 REM REC Listing 2 BBC Acorn version
20 REM Rectifier 1 pulse or 2 pulse
30 REM Evaluate voltage and current
40 V=0 : H=56E-6 : MODE 4 : REM at T=0
50 RS=1 : RD=0.1 : D=0.6 : C=400E-6 : RL=200
90 FOR T=0 TO 3*20E-3 STEP H : X=T*2E4
100 E=100*SIN(314*T+0) : REM 1 pulse
105 REM E=E*SGN(E) : REM 2 pulse
110 PLOT69,X,200 : REM zero line
120 PLOT69,X,2*E+200 : REM in volts
130 PLOT69,X,2*V+200 : REM out volts
140 IS=(E-D-V)/(RS+RD) : IF IS<0 THEN IS=0
145 IL=V/RL : IC=IS-IL : SV=IC/C : REM rate
150 PLOT69,X,IS*20+200 : REM in amps
155 PLOT69,X,IL*20+200 : REM out amps
160 REM At time T+H secs : -
170 LET V=V+SV*H : REM integrate
180 NEXT T : REM describe

```

Listing 14. The prediction program in BBC BASIC.

Program

The above equations can be evaluated for any input emf, e , using a computer and a suitable language. The program shown in Listings 13 and 14 is coded in BASIC for a PC and a BBC Acorn computer respectively, though it is not too difficult to amend it for use with different machines. The statements which carry out the actual plotting of the graphs on the screen are those which will need changing. This program predicts, at successive steps in time, the capacitor potential v (volts), when the applied emf e (volts) is varying sinusoidally. These predicted waveshapes are described in the next section.

The program is based on a FOR...STEP...NEXT loop and contains several very interesting statements. In line 90, the time is stepped from 0 to 3×20

milliseconds, in intervals of 'h' milliseconds, in order to evaluate the equations for three cycles of the input (h has to be relatively 'small', at present $h = 0.056\text{ms}$, which is equivalent to one degree).

At line 100, the applied emf is specified as a sine wave whose angular frequency is 314 radians per second, and whose periodic time is 20ms (a frequency of 50 Hertz).

In line 140 the supply current is deduced. The diode only conducts when $e > (d + v)$, i.e. when forward-biased, which yields a positive (forward) current, hence the IF statement. Line 145 contains the rate of change equation, evaluated as volts per second.

Line 170 has a method for predicting the changing potential. It can be stated as: 'LET the new value of v become the

old value of v plus an increment, where the increment is the product of the rate of change and a step in time.' Provided the step in time, h , is relatively 'small', then the predictions will be useful (compare h of 0.056ms with the charging time constant R.C of 0.44ms).

Waveshapes

The predicted voltage and current waveshapes are shown in Figure 25. The horizontal time axis is 60ms, which corresponds to 3 cycles of the supply emf. The capacitor potential (load voltage) initially increases from 0 to the peak of the supply emf (100 volts) in 5ms (the transient). Then it decreases to 80 volts in approximately 16ms, and then increases to 100 volts again in 4ms (the steady-state). The time constants (R.C) are 0.44ms and 80ms.

The first pulse of current appears for approximately 5 milliseconds, and has a maximum of 11.7A (the transient). Subsequent pulses are 2.5ms and 5.5A repeated every 20ms (the steady-state).

Things to Do

It is left to the reader to investigate a two-pulse or full-wave rectifier, and calculate the average and the rms current values (use 'LET $i_h = i_h + i_s * h$ ' and 'LET $i_{ih} = i_{ih} + i_s * i_s * h$ ' for areas, or 'LET $i_h = i_h + i_s$ ' and 'LET $i_{ih} = i_{ih} + i_s$ ' for ordinates). The effects of using full-wave rectification are plotted in Figure 26. Another thing to do is to calculate the harmonics which represent the steady-state current.

The circuit could be constructed (use an input of 10 volts peak-to-peak in place of 100 volts), and the waveshapes measured using an oscilloscope. Note that the numerical values used have been obtained from the text-book, 'Power Electronics' by Cyril Lander (see Reference 1 (Example 7.15)).

Summary

A computer program has been used to predict the waveshapes associated with a rectifier circuit (single-pulse or half-wave rectified). The input is a sine wave of 100 volts peak-to-peak (70.1 volts rms), at a frequency of 50 Hertz, and the load is 200Ω. After a transient supply current of 11.2A, the load voltage ripples between 100 volts and 80 volts, whilst the steady-state supply current pulses have a maximum of 5.5A. Lastly 'things to do' have been suggested.

Conclusion

These articles have altogether contributed various worked examples in program form (Listings 1-14, prefixed 'RC' (1,2), 'CR' (3,4), 'RL' (5,6), 'RLM' (7,8), 'RLC' (9,10), 'LRC' (11,12), and 'REC' (13,14)), which illustrate how the fundamental rate of change equations can be used and evaluated for any input. The associated computer code consisted of a few statements which are easy to amend for use with different computers.

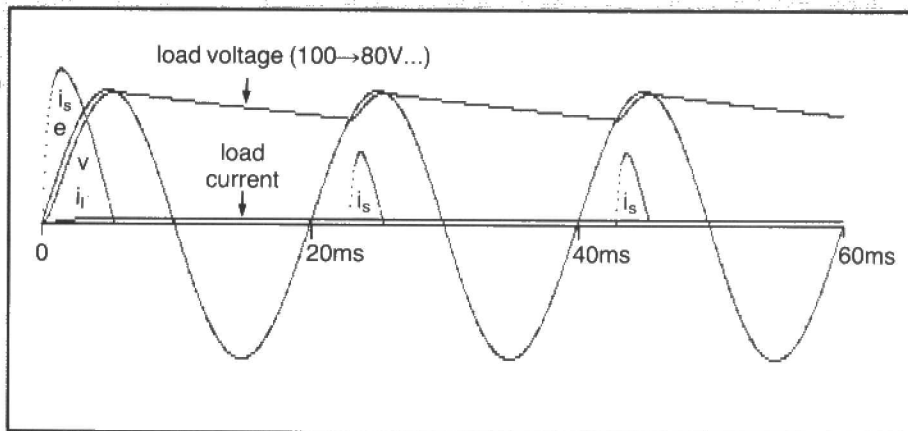


Figure 25. Predicted voltage and current waveshapes for applied emf of $100 \sin 314t$ (50Hz). Time constants, charging, 0.44ms, discharging, 80ms.

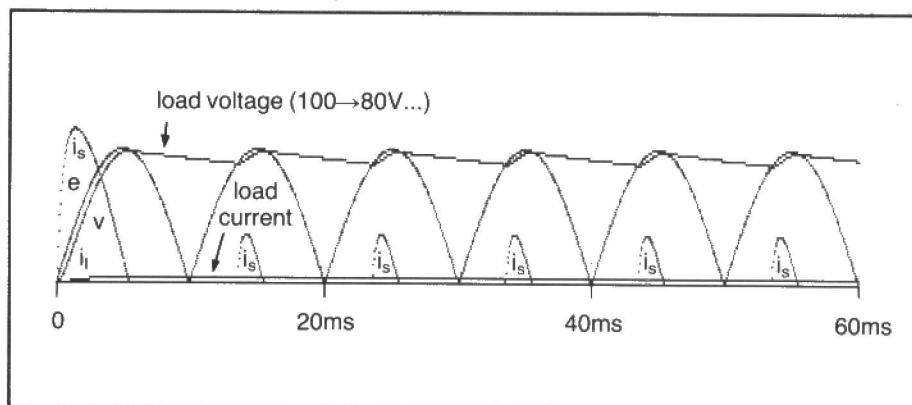


Figure 26. As for Figure 25, but with full-wave rectification.

The examples produced similar rate equations, each of which had a time constant. The waveshapes, relative to the appropriate time constant, were identical for identical inputs. Where the input was a sine wave, the output was sinusoidal. This output consisted of a transient which lasted for approximately five time constants, followed by a steady-state sinusoid. These similar equations can be represented by the general equation:

$sy = (x - y)/\tau$, where x is any input, y is any input and τ is the time constant.

Similar fundamental laws are used in most scientific topics. For instance, a car or motor-bike is a mass, where the fundamental rate of change law is $F = M.sv + r.v$ (where M is the mass, sv represents acceleration as the rate of change of velocity, r = resistance to

movement of car (wind resistance, friction, etc.) and v = velocity of vehicle). One interesting fact arises from the above example; when the vehicle is stationary just before the point of movement (e.g. at the traffic lights), the acceleration is maximum.

The resistor-inductor-capacitor example, with a shunt conductance, could be cascaded to represent a transmission line. A travelling wave should be predicted.

Finally, the author hopes that you have enjoyed this series, and is certain that you will find the associated skills very useful.

Reference

1. Power Electronics by Cyril W. Lander, Published by McGraw-Hill (ISBN 0-07-084123-3 621.3815'2).

COMPETITION WINNERS

'Moving with the Times' London Transport Museum Competition

The questions and correct answers to the London Transport Museum competition which appeared in issue 48 were as follows:

1. Where would you find a beefeater?
The Tower of London.

2. What is Rotten Row famous for?
Horse riding.

3. Where did the nightingale sing?
In Berkeley Square.

4. The Duke of Wellington belonged to which club?
The Athenaeum.

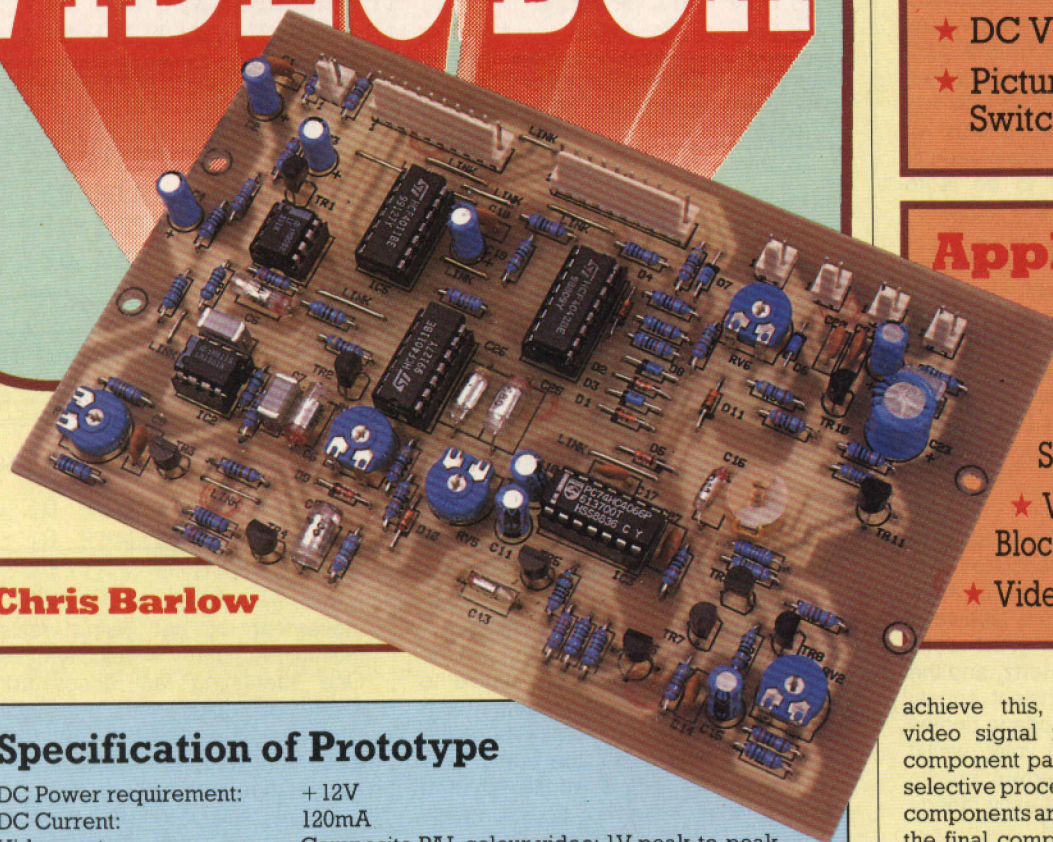
There are six lucky winners of this competition who will each receive four tickets normally costing £7, for two adults

and two children, for a visit to the London Transport Museum at The Piazza, Covent Garden.

The lucky winners are:

P.R. King, Wells, Somerset; K. Hoskin, Haywards Heath, Sussex; Mr. L.C. White, Littlehampton, West Sussex; Mr. R. Andrews, Chingford, London; G.K. Sutherland, Llangefnï, Gwynedd, Wales; Neil Walden, Linton, Cambridgeshire.

The Maplin VIDEO BOX



by Chris Barlow

Specification of Prototype

| | |
|------------------------|---|
| DC Power requirement: | + 12V |
| DC Current: | 120mA |
| Video system: | Composite PAL colour video; 1V peak-to-peak |
| Video gain: | 0dB |
| Frequency bandwidth: | 10MHz |
| Input impedance: | 75Ω (nominal) |
| Output impedance: | 75Ω (nominal) |
| Video control: | Fade to black |
| Synchronized switches: | External control |
| | Video normal or inverted |
| | Video defeat |
| | Colour burst defeat |
| | Output defeat |
| Composite sync: | On/off |
| | External input |
| Timing outputs: | Composite sync |
| (All +12V CMOS) | Inverted composite sync |
| | Vertical sync |
| | Odd/even field index |
| | Video blanking |
| | Inverted video blanking |
| | Colour burst gate |
| | Inverted colour burst gate |

To fade out an audio signal is a relatively simple task, being achieved by reducing the amplitude of all its frequency components at the same time. In its most basic form this can be accomplished by using nothing more than a potentiometer, tapping off the required amount of audio signal. However, composite video signals are made up from several different elements (colour, brightness and timing), and if all

are reduced by the same amount at the same time, the picture will begin to break up long before maximum fade to black is reached.

To maintain a stable picture, a more complex signal processing arrangement is required. The Video Box, shown in block form in Figure 1, permits the reduction in amplitude of picture information, while maintaining the level of the timing signals used to synchronize it. To

FEATURES

- ★ Composite Colour Video In/Out
- ★ Sync In/Out
- ★ Fade to Black
- ★ Normal or Negative Picture
- ★ DC Video Control
- ★ Picture Synchronized Switch Functions

Applications

- ★ Picture Fader
- ★ Video Dubbing
- ★ Video/Sync Splitter/Combiner
- ★ Video Building Block
- ★ Video Enhancement

achieve this, the incoming composite video signal must be split up into its component parts, each of which undergo selective processing. Following this, these components are re-assembled, to produce the final composite output. An additional video inverter has been included, allowing the option for a negative picture to be displayed (useful for home video and long distance/satellite TV enthusiasts!). Apart from its own function as a video fader, the system timing signals have been made available, and as a result the finished unit can be used as a versatile building block for use within other video projects.

Circuit Description

In addition to the block diagram shown in Figure 1, a detailed circuit diagram is provided in Figure 2. These two diagrams should assist you when following the circuit description, or fault-finding in the completed unit. For the circuit to function correctly, it must be powered from a well-regulated +12V DC supply. This supply enters the unit on PL6, and must have the correct polarity (negative on pin 1 and positive on pin 2), otherwise damage may occur to the semiconductors. The main supply decoupling is provided by C2, 15, 19 and C22; with C1, 14, 18, 21 and C27 giving additional high-frequency suppression.

The incoming video is connected to PL1 (pin 1 ground, pin 2 signal), and is terminated by R1. The video signals are AC-coupled via C3 into the video buffer,

an emitter-follower stage based around TR1. This signal is fed to the following video processing circuits:

Sync amplifier IC1.
Normal video switch IC3.
Video inverter amplifier TR4.
Colour burst signal gate IC3.

The function of IC1, the sync amplifier, is to obtain the maximum amount of sync information from the composite video signal. This is brought about by the circuit's combination of gain, DC input bias and frequency response. The cleaned-up and filtered signal is then fed via C7 to the input (pin 2) of the sync separator, IC2. This LM1881 device is a dedicated chip that extracts the timing information (sync) from the processed composite video signal. Four major sync signals are produced by the IC:

1. Composite sync (on pin 1).
2. Vertical sync (on pin 3).
3. Colour burst gate (on pin 5).
4. Odd/even field index (on pin 7).

These timing signals are at +12V CMOS logic levels, and are used by some of the other stages within the Video Box system to synchronize events. They are also available (some with inverted logic) on PL2. Here, the inverted composite sync is provided by IC5b, while the inverted colour burst gate is supplied by IC5c. The inverted composite sync from

pin 4 of IC5b passes through an inverting gate, IC5a, before being mixed back with the picture information at TR11. This gate is used to turn off, or remove, the composite sync from the final composite video output, which appears at pin 2 of PL7. This function is activated when S1 and/or S2 are closed.

The composite sync signal is also used by the input detector (TR2) and video blanking (IC6) circuits. With no signal present at the video input (PL1 pin 2), no sync pulses will be produced by IC2. Under this condition, TR2 will not conduct, so indicator LD1 will not light up – until a signal is available. From the composite sync, the video blanking circuit generates a timing signal, which is used by the main video amplifier to ensure that only picture information is processed. This blanking signal is also available on PL2 pin 9, with its inverted logic condition present on pin 8. The fine tuning of this event is controlled by RV4, which is used to set the start (or left edge), while the end (or right edge) of the picture line is set by RV5.

The vertical sync signal from pin 3 of IC2 is used to control the sync-locked switch functions; video normal/inverse, video defeat, colour defeat and output defeat. This signal is also available on pin 1 of PL2. By locking these switches to the vertical sync, a cleaner and more professional picture change is obtained.

This is achieved by using a quad D-type latch IC4 (4042BE), which has its clock input (pin 5) connected to the vertical sync signal. Only when this signal is present will the output of this IC change state upon operating one of the above function switches, the sync-locked logic outputs from this IC being used to control the system's sync, colour-burst and video processing circuits.

The colour-burst gating signal from pin 5 of IC2 is connected to pin 6 of PL2, and the input of IC5c (which is used as an inverter). The output of this inverter is connected to pin 7 of PL2, and also passes via R34 to the colour-burst signal gate IC3. However, before it reaches its final destination it can be interrupted by being pulled down to ground by the colour-burst and/or output defeat switches.

The odd/even field index signal from pin 7 of IC2 is not used by the Video Box. However, it is available on pin 2 of PL2 for possible use in additional circuitry. For example, this output could be useful in frame memory storage applications, or in extracting test signals that may occur only in alternate fields.

There are two paths that the video signal can take on its way to the main video processing amplifier, both of which pass through IC3. This analogue switching device is used to select the normal or inverted (picture negative) video infor-

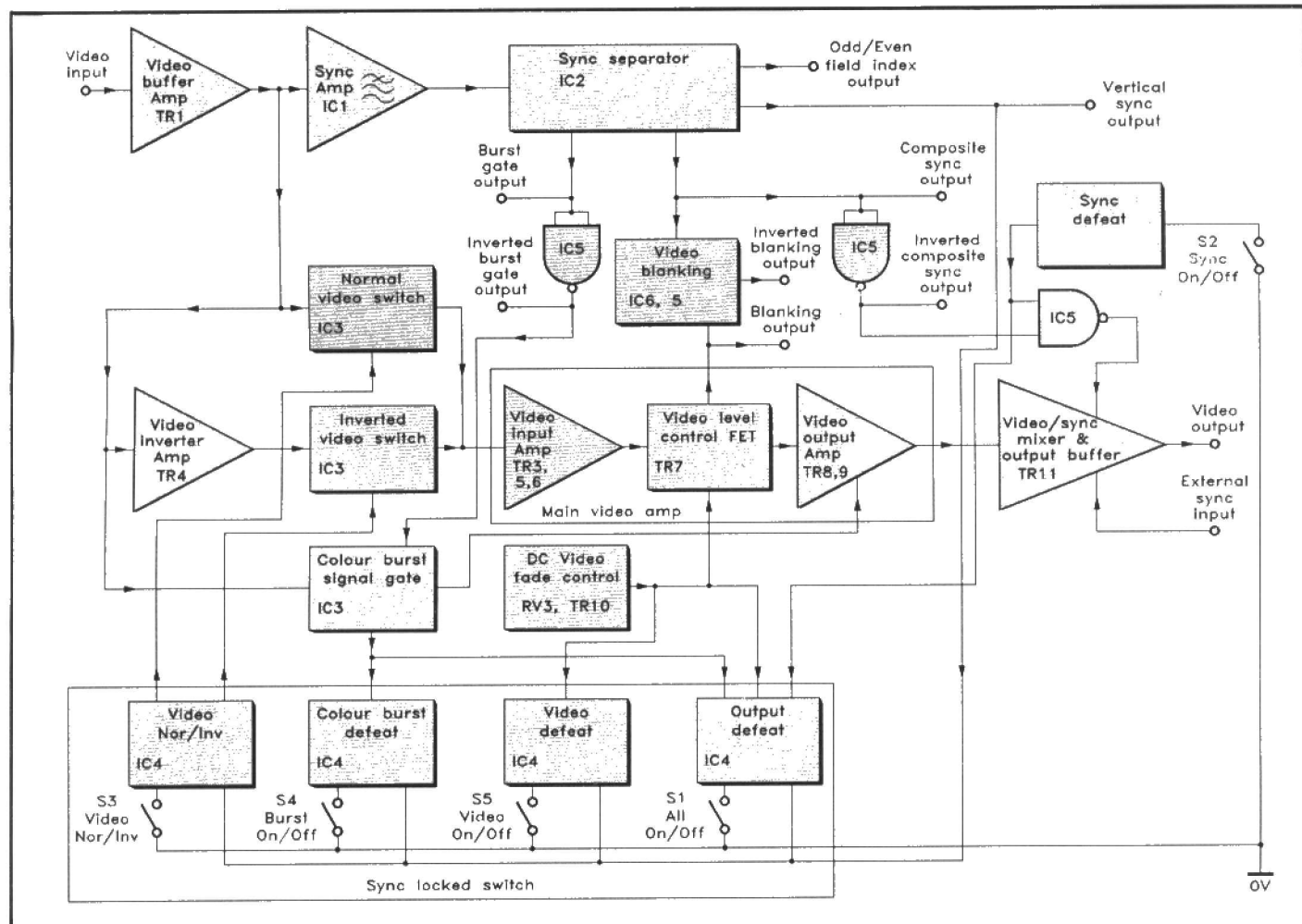


Figure 1. Block diagram.



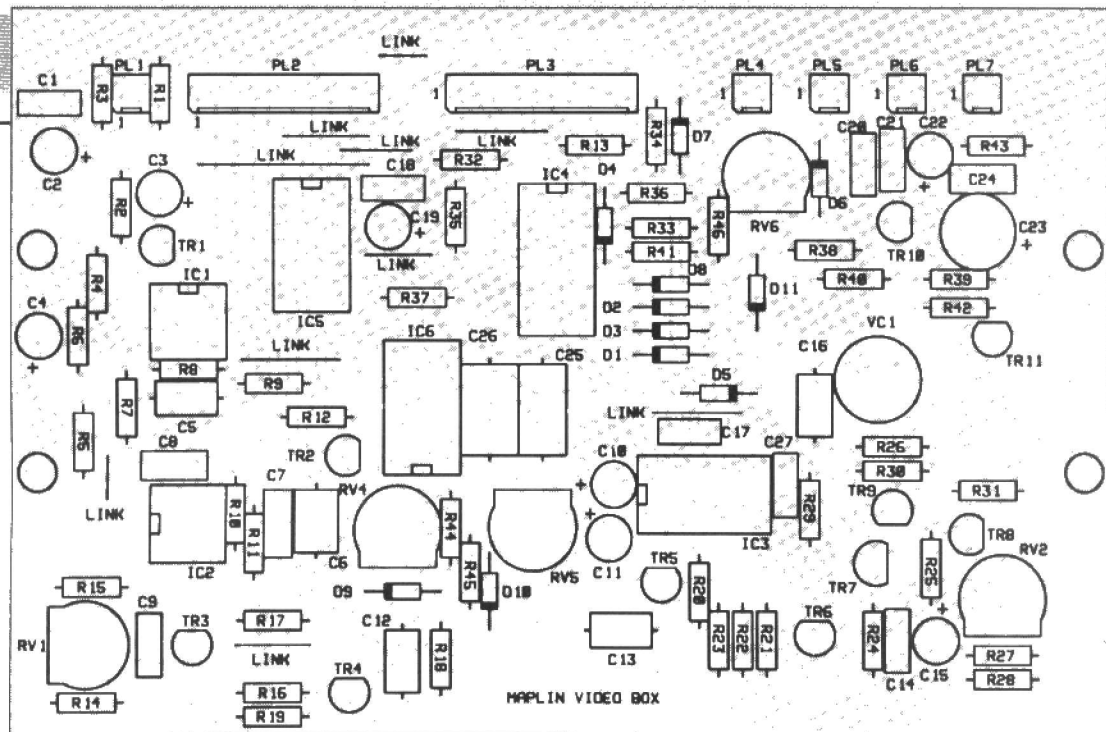


Figure 3. PCB legend and track.

mation, and is controlled by two of the logic outputs from IC4 (S3). When the normal (or non-inverted) signal is selected, the signal path is from the output of the video buffer amp, TR1, to the input of the main amp, TR5. When the inverted signal is selected, the video path is from the output of the video inverter amp, TR4, to the input of the main amp, TR5. The DC bias for both TR4 and TR5 is provided by TR3, and is set by RV1.

The colour-burst signal must remain at a constant level as the video picture information is reduced. Otherwise, the monitor/VCR will try to over-compensate by increasing the colour intensity as the video level is reduced. Eventually, its colour-killer circuit will operate. At the

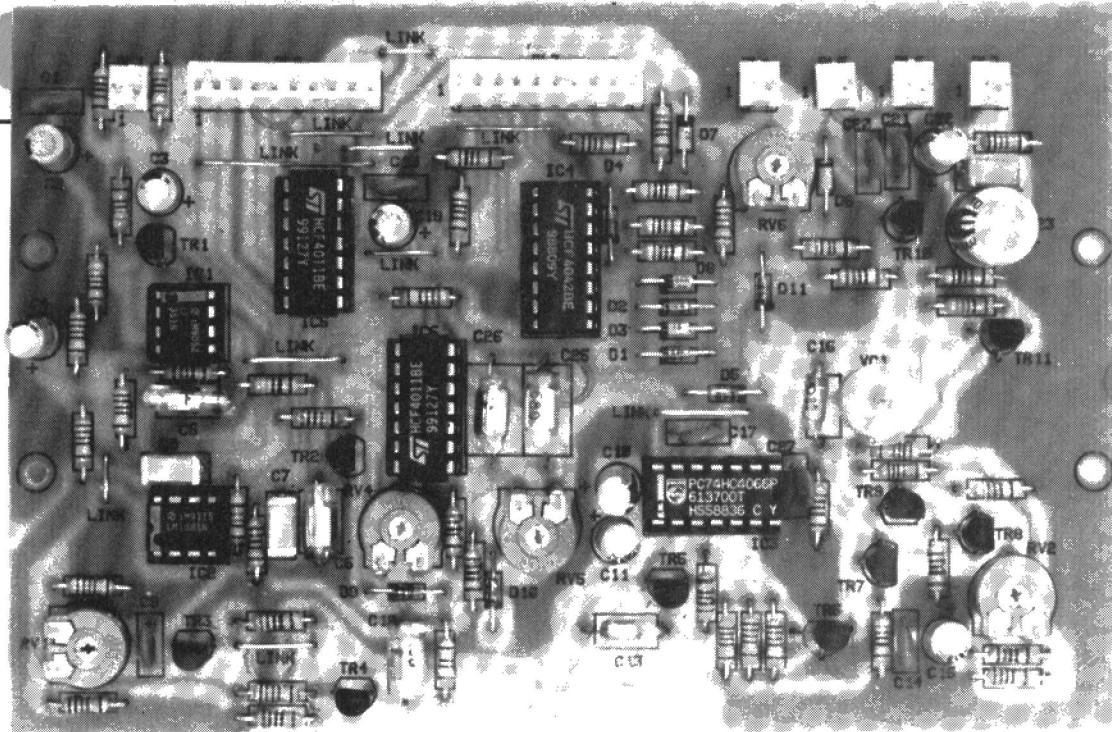
point just before this threshold is reached, the colour video information will appear very noisy (when viewed on a monitor) before suddenly cutting out, leaving a black-and-white (monochrome) picture on the screen. The colour-killer circuit is included by the majority of video/TV equipment designers to accommodate the possibility of a monochrome signal, or if the overall signal is too weak/noisy to reproduce a good enough quality colour picture.

The colour-burst is maintained by gating the composite video signal from TR1 at a precise moment in time, and then re-combining it after the video level control circuit, TR7. This signal gating is achieved by IC3, which receives its

switching control signal from the logic output of IC5c. However, it can be removed if the colour-burst defeat switch, S4, and/or output defeat switch, S1, is activated.

The main video level processing amplifier consists of four stages:

1. The DC bias for the input buffer is supplied by TR3. The output of this stage is determined by the level of voltage applied to the base of TR3 by RV1.
2. The input buffer, formed by TR5 and TR6, then conditions the video signal into a form suitable for feeding TR7, the video level control FET.
3. TR7 is controlled by the DC voltage



ACTUAL
SIZE

Photo 1. Completed PCB.

applied to its gate; the higher this is, the higher the amplifier gain will be. This voltage is supplied by the DC video fade control transistor, TR10. A potential divider on the base of TR10 is created by using three resistors: a fixed resistor, R38; a preset, RV6; and a rotary (or slide) control, RV3. The combined value of R38 and RV6 sets the maximum voltage limit, which corresponds to the maximum video level. However, as the value of RV3 decreases, this voltage will drop until the zero point is reached, corresponding to minimum video level. The voltage output from TR10 is grounded by the video blanking circuit, which is based around IC5d and IC6. This has the effect of turning off the main video amplifier during the sync and colour-burst time slots. The voltage can also be manually grounded if the video defeat (S5) and/or output defeat (S1) switches are activated. Additionally, it can be grounded by an external influence applied to pin 2 of PL5.

4. The output amplifier, comprised of TR8 and TR9, receives the video signals from TR7, and the colour-burst signal from IC3. Two capacitors, C16 and VC1, are used to set the injection level of the colour burst. A second DC bias control, RV2, sets the black level of the video signal.

The output from the main video processing amplifier is supplied to TR11, where the previously extracted composite sync is mixed with it to produce the final composite colour video output signal. As well as mixing the two signals, TR11 acts as a buffer, providing a low impedance 75R output drive which passes through C23 and C24, onto pin 2 of PL7. This video/sync mixer stage can also be supplied with external sync information applied to pin 9 of PL3.

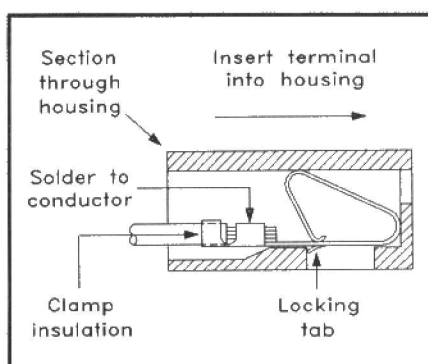


Figure 4. Terminating the wires.

PCB Assembly

All the information required to help you with soldering and assembly techniques, should you need it, can be found in the Constructors' Guide included in the kit (also separately available as stock code XH79L). The printed circuit board (PCB) is a single-sided glass fibre type, chosen for maximum reliability and mechanical stability. Removal of an incorrectly-fitted component can be fairly difficult without damaging it, or the PCB, in some way, so please double-check each component type, value, and polarity (where appropriate), before soldering! The PCB has a legend to assist you in correctly positioning each item (see Figure 3). It is usually easier to start with the smaller components, such as the resistors. Next, mount the ceramic, polylayer, polystyrene and electrolytic capacitors. All the diodes have a band at one end; be sure to position them according to the legend. When installing the transistors, make certain that each case matches its outline. This also applies to the IC sockets and 'Minicon' connectors, where you should match the notch with the block on the legend. The next components to be installed are the five preset resistors

(RV1, 2, 4, 5, 6) and the trimmer capacitor, VC1. Only after all the other components have been fitted should you then carefully insert the relevant ICs into their sockets, making sure that you correctly orientate them. Finally, do not forget to fit all ten wire links. These can be made from component lead off-cuts, or the 22SWG tinned copper wire included in the kit. Photo 1 shows in detail the completed PCB assembly.

This completes the assembly of the PCB, and you should now check your work very carefully, making sure that all the solder joints are sound. It is also very important to ascertain that the solder side of the circuit board does not have any trimmed component leads protruding by more than 2mm, as a short-circuit may otherwise result.

Final Assembly

No specific box has been designated for the project, as your finished unit could contain other PCBs (e.g. video digitiser and computer cards). However, the basic unit fitted nicely in to an ABS console M6006 (stock code LH66W). This, and the additional connectors and hardware, are listed under 'Optional' (Not in kit), in the parts list. Once you have completed the mechanical assembly of the unit, you should check your work very carefully before proceeding to the wiring stage.

Wiring

If you purchase the Maplin kit (stock code LP48C), it should contain a one metre length of ten-way ribbon cable. This is used for all the DC connections. However, no specific colour has been designated for each wire connection; this choice is left entirely to you. Coloured wire is used to simplify matters, making it easier to trace separate connections to off-board components, just in case there

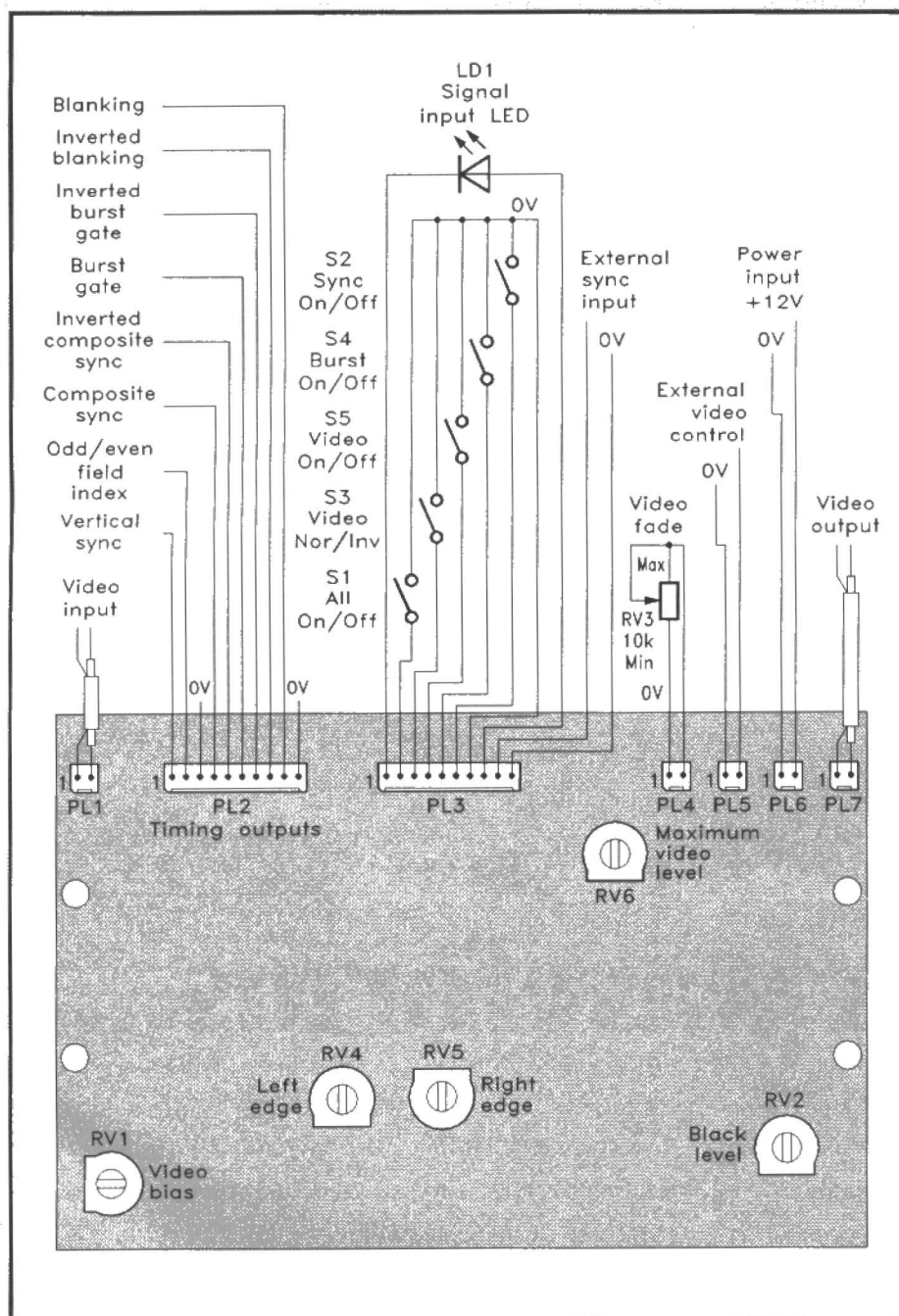


Figure 5. Wiring.

is a fault in any given part of the circuit. Miniature 75Ω coaxial cable is used for the video in/out signals on PL1 and PL7, and it is most important that the braided screen should not be able to come into contact with the centre conductor, or anything connected to it. All the wire connections to the PCB are made using 'Minicon' connectors; the method of installing these is shown in Figure 4. A wiring diagram, which shows all of the interconnections on the PCB, is given in Figure 5. The actual physical connections to the rotary video fade potentiometer, and the optional slide control, are shown in Figure 6.

This completes the wiring of the Video Box and you should now check your work very carefully, making sure that all the solder joints are sound.

Testing and Alignment

The initial DC testing procedure can be undertaken using the minimum amount of equipment. You will need a multimeter and a well-regulated +12V DC power supply, capable of providing at least 150mA. All of the following readings are taken from the prototype using a digital multimeter, and some of the readings you obtain may vary slightly, depending upon the type of meter used!

Before you commence testing the unit, set the PCB presets (RV1,2,4,5,6 and VC1) to their half-way positions, and the the off-board function switches (S1,2,3 and 4) to their 'open' or 'off' positions. Ensure that the rotary (or slide) video fade control, RV3, is set to its maximum level, as shown in Figure 6. DO NOT connect any power or video signals to the unit at this stage of testing.

The first test is to ensure that there are no short-circuits before connecting the unit to a DC power supply. Set your

TERMINAL BLOCKS

| PL1 | PL2 | PL3 | PL4 | PL5 | PL6 | PL7 |
|------------|-------------|---------------|--------------|--------------|-------------|------------|
| pin 1 = 0V | pin 1 = 0V | pin 1 = 10-8V | pin 1 = 0V | pin 1 = 0V | pin 1 = 0V | pin 1 = 0V |
| pin 2 = 0V | pin 2 = 12V | pin 2 = 12V | pin 2 = 4-7V | pin 2 = 0-5V | pin 2 = 12V | pin 2 = 0V |
| | pin 3 = 0V | pin 3 = 12V | | | | |
| | pin 4 = 0V | pin 4 = 12V | | | | |
| | pin 5 = 12V | pin 5 = 12V | | | | |
| | pin 6 = 12V | pin 6 = 12V | | | | |
| | pin 7 = 0V | pin 7 = 0V | | | | |
| | pin 8 = 12V | pin 8 = 12V | | | | |
| | pin 9 = 0V | pin 9 = 0V | | | | |
| | pin 10 = 0V | pin 10 = 0V | | | | |

SEMICONDUCTORS

| TR1 | TR2 | TR3 | TR4 | TR5 | TR6 | TR7 | TR8 | TR9 | TR10 | TR11 |
|----------|-----------|----------|----------|----------|----------|----------|-----------|-----------|----------|----------|
| E = 6-3V | E = 0V | E = 3-2V | E = 0-6V | E = 3-9V | E = 3V | S = 3V | E = 3V | E = 11-5V | E = 4V | E = 3-2V |
| B = 7V | B = 0-1V | B = 3-8V | B = 1-3V | B = 3-2V | B = 3-6V | G = 0-5V | B = 3-6V | B = 10-9V | B = 4-7V | B = 2-5V |
| C = 12V | C = 10-8V | C = 12V | C = 8-6V | C = 3-6V | C = 12V | D = 3V | C = 10-9V | C = 2-5V | C = 12V | C = 0V |

| IC1 | IC2 | IC3 | IC4 | IC5 | IC6 |
|-------------|-------------|--------------|--------------|--------------|--------------|
| pin 7 = 12V | pin 8 = 12V | pin 14 = 12V | pin 16 = 12V | pin 14 = 12V | pin 14 = 12V |

Table 1. DC test measurements (read with a digital voltmeter).

Continued on page 72.

Stray Signals

by Point Contact

'Son of ASCII'; no, it's not the latest space age Odyssey, but a term PC has coined to describe Unicode. ASCII is the almost universal character code used by computers – if we ignore one or two special purpose or manufacturer-specific ones such as EBCDIC. With its 256 codes, extended 8-bit ASCII can represent the Roman alphabet in both upper and lower case, numerals, various control codes and still have space for various language-specific letters found in German, Romance and Scandinavian languages. But this still covers only a handful of languages, mainly of European origin – what about scripts used for the languages of the Middle and Far East? Enter Unicode, developed by a consortium of leading computer companies and software houses, as the new universal language. As it uses a word (16 bits) for each character, rather than an 8-bit byte, it can represent 65,536 separate codes or symbols. 16 bits is no great bother to the more powerful present-day computers, which have data buses that are 16, 24 or 32 bits wide. Unicode can thus represent all the living languages of the world (with Classical Greek thrown in for good measure), after a bit of ingenious shoe-horning. After all, Chinese alone needs over 30,000 characters, not to mention Japan, Korea and Taiwan, but fortunately it turns out that two-thirds of their 'ideograms' are common to all or most of these languages. November 1990 saw the final draft, with final review complete February 1991. June 1991 was scheduled for the publication of the finished standard, but it won't help this humble scribe, as PC's PC, on which these lines are hammered out, is an old-fashioned 8086 based 8-bit machine. So I shall just continue to gnash my teeth when needing one of the Greek characters such as lower case rho, used as symbols in engineering, which are not available in the IBM implementation of ASCII.

It's funny how the human mind can jump to a conclusion and continue doggedly to act upon it, only realising that it is false much later on, when things stubbornly refuse to work as they should. I know of an engineer who made a faux pas of ridiculous proportions



and then spent ages trying to get his circuit to work. It was a synthesised oscillator covering 80 to 160MHz and using that good old standby, the Motorola MC145152 synthesiser controller chip, with a 10kHz comparison frequency. As the MC145152 only works up to about 15MHz, a prescaler was necessary and a 145152 can control a dual-modulus one, so maintaining the step size resolution. Now he had just very successfully employed a Siemens SDA4212 two modulus prescaler, with the modulus control pin strapped permanently to +5V to force the chip to divide by 64 all the time, in an ingenious divide by 1000 prescaler operating up to 1.2GHz. This was used to extend the range of his 10MHz frequency meter. So he used the same chip as a $\div 64/\div 65$ prescaler in his synthesiser, under control of the

MC145152's modulus control output pin. Unfortunately, the VCO control loop was unstable and all measures taken to tame it proved utterly fruitless, so eventually the project was temporarily shelved. Only some time later, when checking out the SDA4212 for use in yet another project, did he notice that it was not designed as a $\div n/\div (n+1)$ dual modulus prescaler at all; it offered a choice of two fixed divide ratios, $\div 64$ or $\div 256$. No wonder the poor MC145152 couldn't understand why the prescaler was misbehaving! I must say that, with all due respect to the engineer concerned, I have never heard of a bigger blunder. Er – oh dear, you've guessed who it was!

Yours sincerely,

Point Contact

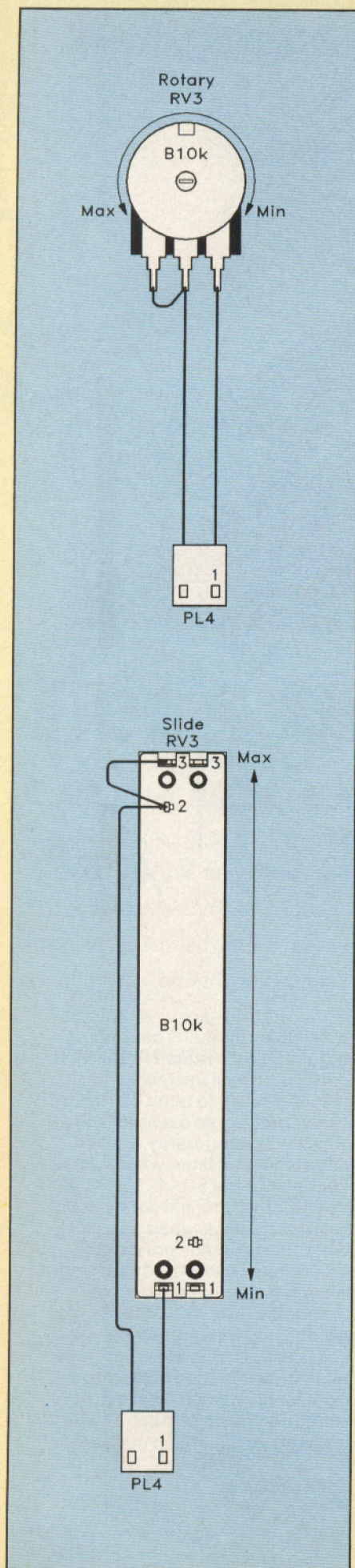


Figure 6. Video fade potentiometers.

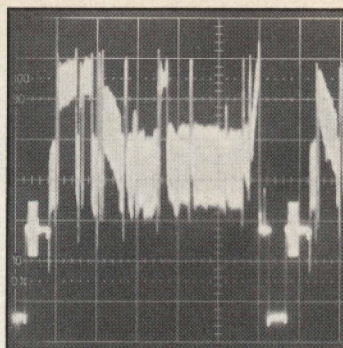


Photo 2 (above right): Correctly aligned picture (monitor screen).

Photo 3 (above left): Correct composite video waveform (CRT display).

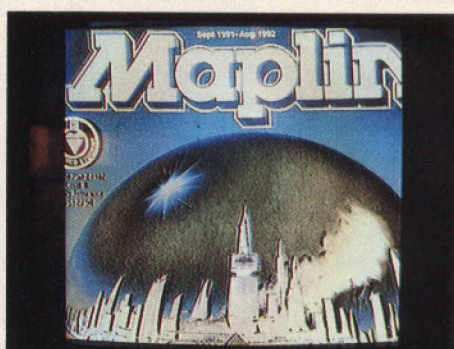
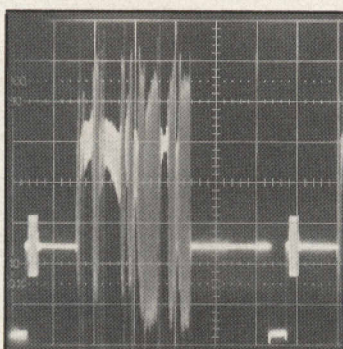


Photo 4 (above right): Incorrectly aligned picture (monitor screen).

Photo 5 (above left): Incorrectly aligned picture (CRT display).

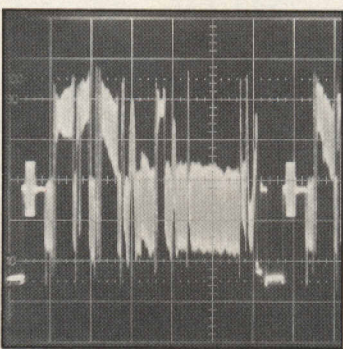


Photo 6 (above right): Incorrectly aligned black-level - too low (monitor screen).

Photo 7 (above left): Incorrectly aligned black-level - too low (CRT display).

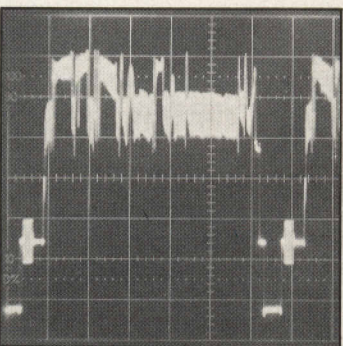


Photo 8 (above right): Incorrectly aligned black-level - too high (monitor screen).

Photo 9 (above left): Incorrectly aligned black-level - too high (CRT display).

multimeter to read 'OHMS' on its resistance range, and connect the two test probes to pin 1 and pin 2 of PL6. With the probes either way round, a reading greater than 60Ω should be obtained. If a much lower reading is registered, then check that solder joints and component leads are not shorting between tracks. Next, monitor the supply current; set your meter to the DC mA range and place it in series with the positive line, pin 2 of PL6. Connect up and switch on your regulated +12V power supply, ensuring correct polarity. A current reading of approximately 110mA should be obtained, and the signal input indicator LD1 should not be illuminated. Switch off, disconnect the power supply and remove the meter.

Reconnect the power supply, and set your multimeter to read DC volts. All of the voltages are positive with respect to ground, so connect your negative test lead to any of the 0V ground pins on the terminal blocks:

| | |
|---------------------|-----------|
| PL1 pin 1 | PL5 pin 1 |
| PL2 pin 3 or pin 10 | PL6 pin 1 |
| PL3 pin 7 or pin 10 | PL7 pin 1 |
| PL4 pin 1 | |

The voltages present on the PCB assembly should approximately match the readings shown in Table 1. When these tests have been completed successfully, remove power from the unit.

To commence the video testing and alignment, you will require some additional video equipment and test gear. You will need a source of composite colour video which could be a VCR, TV tuner, video camera or pattern generator. To observe the resultant output, you will require a composite colour video monitor (or a TV/VCR with a video input) and a 20MHz oscilloscope with TV coupling. If you haven't got access to the more exotic video test gear, DON'T PANIC! – it is still possible to obtain acceptable results using only the video equipment and your own visual judgment. The picture image used in our tests was taken from a colour video camera, and is of the 1992 Maplin catalogue.

Connect the video source to the input (PL1), and the monitor to the output (PL7). If you have an oscilloscope, set it up as follows: TV coupling; horizontal time-base $10\mu\text{s}$; auto-trigger with negative polarity; vertical input 0.2V/div DC coupled. Next, connect its vertical input to the video output on PL7.

Ensure that all of the function switches on the Video Box are set to their 'off' or 'open' positions, and that the video fade control, RV3, is set to maximum. Apply power to the unit and, if all is correct, then LD1 should light and you should observe a clear high-quality picture on the monitor screen (see Photo 2) and a composite video waveform on the oscilloscope display (see Photo 3). However, this is unlikely since none of the presets have been critically adjusted, and so the picture is more likely to resemble the one shown in Photos 4 and 5. Each preset will affect a particular parameter of the video signal. Interaction may occur

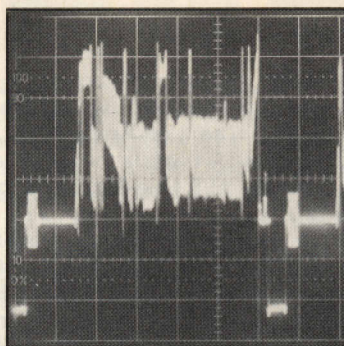


Photo 10 (above right): Left-hand edge RV4 (monitor screen).
Photo 11 (above left): Left-hand edge RV4 (CRT display).

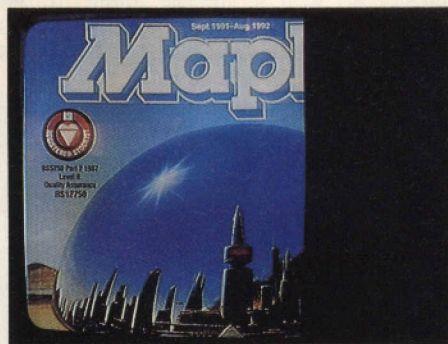
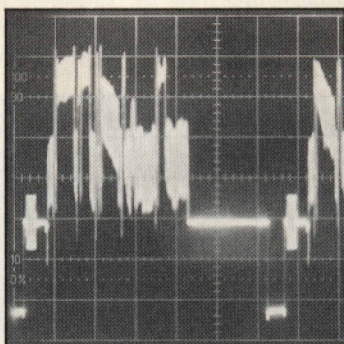


Photo 12 (above right): Right-hand edge RV5 (monitor screen).
Photo 13 (above left): Right-hand edge RV5 (CRT display).

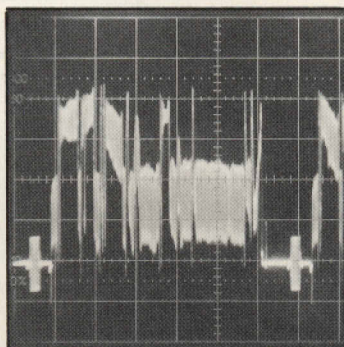


Photo 14 (above right): Composite sync removed (monitor screen).
Photo 15 (above left): Composite sync removed (CRT display).

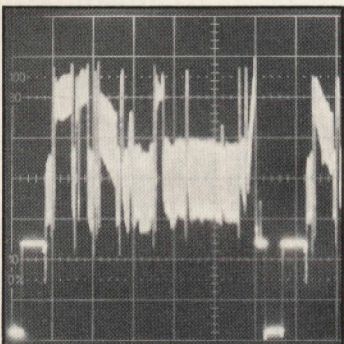


Photo 16 (above right): Colour-burst removed (monitor screen).
Photo 17 (above left): Colour-burst removed (CRT display).

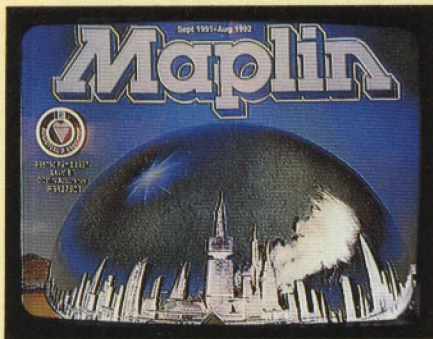


Photo 18. Picture distortion (monitor screen).

between several of these adjustments, and so progressive re-calibration may be required.

The first adjustment is to set the correct input and black-level bias points. As RV1 is turned anticlockwise, the picture quality will progressively deteriorate as the level of high-frequency distortion increases. This will continue until the picture inverts on highlights, as shown in Photo 18. Turn RV1 clockwise until this effect is corrected; over-adjustment of this preset will have an adverse result on the inverse-video mode. The black-level is set by RV2, and as this is turned anticlockwise the video information will progressively drop down into the sync region, eventually causing picture break-up (see Photos 6 and 7). If this preset is turned too far clockwise, the picture will look washed out (see Photos 8 and 9). RV1 and RV2 do have a small effect on each other, and so progressive re-adjustment may be necessary.

The next parameter to correct is the amount of picture information shown on the screen. The left-hand edge is adjusted using RV4, while the right-hand edge is set by RV5 (see Photos 10 to 13 inclusive).

If an oscilloscope is not available, RV6 and VC1 will not be as easy to set up as the other presets. This is because RV6 sets the maximum video level, and most modern equipment can accept a significantly over-driven input, particularly VCRs, which feature a video AGC circuit. The colour-burst signal level, set by VC1, is used to control the colour intensity of the picture. To calibrate the unit to give a standard 1V peak-to-peak video output, an oscilloscope will be required (see Photo 3). However, a rough setting can be made by comparing the relative bright-

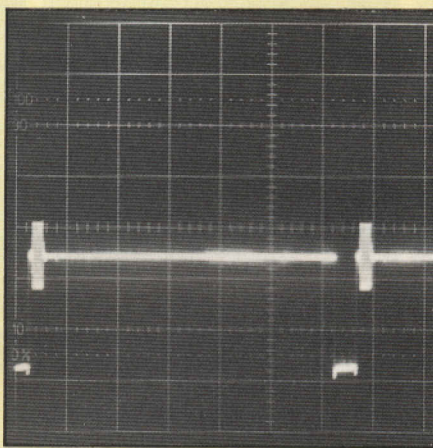


Photo 19. Video fade to black (CRT display).



Photo 20. Inverted picture (monitor screen).

ness and colour intensity of the direct video signal to the processed one.

Finally, test the following functions:

1. Range-test the video fade control, RV3. The control should give complete control from maximum picture level, down to a black screen (as shown in Photo 19).
2. Output defeat switch, S1. All video signal components should be blocked when S1 is closed.
3. Sync defeat switch, S2. The composite sync pulses should be removed when S2 is closed, resulting in a slipping picture, as shown in Photos 14 and 15.
4. Video invert switch, S3. Picture should become a 'negative' image when S3 is closed - see Photo 20.
5. Colour-burst defeat switch, S4. The picture should change to a black-and-white one when S4 is closed; refer to Photos 16 and 17.
6. Video defeat switch, S5. Only the sync and colour burst information should be passed when S5 is closed, producing a blank screen, as can be seen from Photo 15.

VARIOUS

FOR SALE, LM3750 12V Receiver, fully completed but not working. £10 o.n.o. Write to: P. Watson, 24 Amberton Place, Leeds, LS8 3AH.

COMPONENTS FOR SALE - send SAE for list to Alan Auden, 206 Ellerdine Road, Hounslow, TW3 2PX.

SCOPEX 4D10A OSCILLOSCOPE. 10 MHz Dual Beam, good condition, with leads and manual, boxed. £120 o.n.o. Phone (0253) 854486 evenings or weekend (Blackpool).

GIANT CLEAROUT! Long list of unused components including ICs, capacitors, resistors. Some in large quantities - all at bargain prices. Send SAE for list. M.J. Dean, 'Blenheim', Walton Lane, Bosham, Chichester, West Sussex, PO18 8QF.

PANASONIC HI-FI STEREO VIDEO RECORDER. Converted for NICAM with outboard Maplin decoder. New video heads, belts and pinch wheel. 2 remote controls. £199. Tel: (0272) 685767 evenings (Bristol).

MAPLIN ORGAN FOR SALE. 2 keyboards, 8 pedals, light oak cabinet. With headphones, matching stool and all instructions. In good condition. Any reasonable offer accepted. V.L. Robinson, 17 Carisbrooke Road, Cambridge, Cambs. CB4 3LP.

CLASSIFIED

If you would like to place an advertisement in this section, here's your chance to tell our 33,837 readers what you want to buy or sell, or tell them about your club's activities - absolutely free of charge. We will publish as many advertisements as we have space for. To give a fair share of the limited space, we will print 30 words free of charge. Thereafter the charge is 10p per word. Please note that only private individuals

will be permitted to advertise. Commercial or trade advertising is strictly prohibited.

Please print all advertisements in bold capital letters. Reference Boxes are available at £1.50 each. Please send replies to address below quoting Reference Box Letters. Please send your advertisement with any payment necessary to: Classifieds, Maplin Mag., P.O. Box 3, Rayleigh, Essex SS6 8LR.

VIEWDATA TERMINAL with keyboard and modem - needs password. 3 years old, £20. Tel: (0924) 406377 (West Yorks.).

LASER AND PSU £60 o.n.o.; Casio TV6500 LCD TV (needs backlight) - cost £150, sell £100 o.n.o.; 3 x Spectrum 48K (need Z80s) - offers; 8 x Walkman - offers; B/W security

camera - offers. Tel: Don (0303) 41202.

SCOPEX 4D10A 10 MHz dual-beam oscilloscope £135. Heathkit V-7AU electronic multimeter £23. Portable stereo graphic equaliser £25. Ultrasonic remote control switch £17. Cathay cassette recorder £15. Tel: (0502) 566026.

WANTED

WANTED - PSU, battery back-up and relay output diagrams for the UA3730 IC. All details and diagrams appreciated. Please write to M. Myland, 45 Amberton Road, Leeds, LS8 3AJ.

WANTED: Circuit for the switch-mode PSU used in the BBC-B. All expenses or will exchange for a SEISMOMETER sensitive to footsteps or earthquakes! Tel: (0767) 50432 Ian (senior).

WANTED: Chapman valve stereo multiplex adaptor made for models FM1000, FM1005 and S6BS FM Mk2 tuners. Working or resurtable (any condition) (Circa 1956). Frank Cosgrove. Tel: (0202) 432973.

URGENTLY WANTED: User Guide and/or software for ORIC-1 computer. Send details to: G. Mills, Room 11, 23 Fishergate Hill, Preston, Lancs. PR1 8JB.

WANTED: 286 or 386 motherboard, with processor and at least 1Mb of RAM. Phone Jamie on (081) 505 0344.

COULD SOMEBODY PLEASE supply me with information on these ICs, used in the Atari XL series of microcomputers: 8323 (CPU); AM18339MAB; AM18339MAL. Also data on any other home computers. Tel: (0924) 406377 (West Yorks.).

Using the Video Box

There are two major factors which can cause a reduction in performance from the Video Box. Firstly, if a +12V DC power supply with poor smoothing or regulation is used, some of the functions will not work properly and the overall picture quality will suffer. For this reason, it is strongly recommended that if a ready-built DC supply is used, it should be the regulated 300mA 12V type featured in the 1992 Maplin Catalogue (stock code YB23A). If you are constructing your own, it should incorporate a +12V regulator, such as the μ A78M12UC (stock code QL29G). Please note that the Video Box is NOT reverse-polarity protected, and so damage will occur to the circuit if the power supply connec-

tions are reversed. Secondly, if an inferior video signal is fed into the unit then a poor quality signal will be produced. This can result in a dim, fuzzy and possibly unstable picture on the monitor screen.

The main function of the Video Box is to provide the ability for fading the picture information down to a blank screen. This effect can be used as a 'fade-in' or 'fade-out' on dubbed recordings (e.g. camcorder to VCR), lending a more professional appearance to your video productions. The whole picture, but not the sync, can be suddenly switched on and off by operating the video defeat switch, S5. The output defeat switch, S1, can appear to have a similar effect, but as it switches off all the signal components, your video equipment can take some time to re-synchronize to the signal.

Two additional video effects have been provided for. When operated, the picture inverse switch, S3, produces a 'negative' image. This unusual effect has often been exploited by pop video and sci-fi film makers. The colour burst defeat switch, S4, should have the effect of turning off the colour circuits within your video equipment. This function is commonly referred to as the 'colour-killer' circuit (as discussed earlier), and when activated has the effect of producing a black-and-white picture. It is unlikely that you will ever need to use the sync defeat switch, S2, as this removes the composite sync from the video signal. However, if the Video Box is used as part of a larger video system, it may be necessary to switch off its own recovered sync, or possibly feed in external sync.

VIDEO BOX PARTS LIST

RESISTORS: All 0.6W 1% Metal film (Unless Specified).

| | | | |
|---------------------------------|---------------------|----|---------|
| R1 | 82 Ω | 1 | (M82R) |
| R2 | 6k8 | 1 | (M6K8) |
| R3,29,32,33,35, 36,39,41 | 10k | 8 | (M10K) |
| R4,24,42 | 470 Ω | 3 | (M470R) |
| R5,6,7,13,14,16, 21,22,28,43 | 1k | 10 | (M1K) |
| R8,11,27,40 | 2k7 | 4 | (M2K7) |
| R9 | 560 Ω | 1 | (M560R) |
| R10 | 560k | 1 | (M560K) |
| R12,34,38,44 | 4k7 | 4 | (M4K7) |
| R15,23 | 220 Ω | 2 | (M220R) |
| R17 | 1k5 | 1 | (M1K5) |
| R18 | 390 Ω | 1 | (M390R) |
| R19 | 2k2 | 1 | (M2K2) |
| R20,25 | 100 Ω | 2 | (M100R) |
| R26 | 270 Ω | 1 | (M270R) |
| R30 | 150 Ω | 1 | (M150R) |
| R31 | 820 Ω | 1 | (M820R) |
| R37,46 | 15k | 2 | (M15K) |
| R45 | 27k | 1 | (M27K) |
| RV1,2 | 1k Hor Encl Preset | 2 | (UH00A) |
| RV3 | 10k Min Pot Lin | 1 | (JM71N) |
| RV4,5,6 | 22k Hor Encl Preset | 3 | (UH04E) |

CAPACITORS

| | | | |
|----------------------------|--------------------------|---|---------|
| C1,9,14,17,18, 20,21,27 | 100nF Minidisc | 8 | (YR75S) |
| C2,3,4,10,11,15, 19,22 | 47 μ F PC Elect 25V | 8 | (FF08J) |
| C5,13 | 22pF Polystyrene | 2 | (BX24B) |
| C6 | 560pF Polystyrene | 1 | (BX33L) |
| C7,8,24 | 100nF Polylyer | 3 | (WW41U) |
| C12 | 100pF Polystyrene | 1 | (BX28F) |
| C16 | 68pF Polystyrene | 1 | (BX27E) |
| C23 | 470 μ F PC Elect 16V | 1 | (FF15R) |
| C25 | 680pF Polystyrene | 1 | (BX34M) |
| C26 | 2n2F Polystyrene | 1 | (BX37S) |
| VC1 | 65pF Trimmer | 1 | (WL72P) |

SEMICONDUCTORS

| | | | |
|------------------|----------|---|---------|
| IC1 | LF351 | 1 | (WQ30H) |
| IC2 | LM1881N | 1 | (UL75S) |
| IC3 | 74HC4066 | 1 | (UF10L) |
| IC4 | 4042BE | 1 | (QX19V) |
| IC5,6 | 4011BE | 2 | (QX05F) |
| TR1,2,3,4,6,8,10 | BC184L | 7 | (QB57M) |
| TR5,9,11 | BC214L | 3 | (QB62S) |

| | | | |
|------------------|---------|---|---------|
| TR7 | BF244A | 1 | (QF16S) |
| D1,2,4,5,9,10,11 | IN4148 | 7 | (QL80B) |
| D3,6,7,8 | BAR28 | 4 | (QQ13P) |
| LD1 | LED Red | 1 | (WL27E) |

MISCELLANEOUS

| | | | |
|-------------|----------------------|--------|---------|
| PL1,4,5,6,7 | Minicon Plug 2 Way | 5 | (RK65V) |
| PL2,3 | Minicon Plug 10 Way | 2 | (RK66W) |
| | Minicon Hsng 2 Way | 5 | (HB59P) |
| | Minicon Hsng 10 Way | 2 | (FY94C) |
| | Minicon Terminal | 3 | (YW25C) |
| | Miniature Coax | 1m | (XR88V) |
| | Ribbon Cable 10 Way | 1m | (XR06G) |
| | TC Wire 0.71mm 22swg | 1 Reel | (BL14Q) |
| | DIL Socket 8-Pin | 2 | (BL17T) |
| | DIL Socket 14-Pin | 3 | (BL18U) |
| | DIL Socket 16-Pin | 1 | (BL19V) |
| | PCB | 1 | (GE85G) |
| | Instruction Leaflet | 1 | (XT04E) |
| | Constructors' Guide | 1 | (XH79L) |

OPTIONAL (Not in Kit)

| | | | |
|-----|--|---|---------|
| RV3 | Min Slide Pot Lin 10k | 1 | (JM85G) |
| | Slide Knob B | 1 | (YG09K) |
| | Knob K14B | 1 | (FK39N) |
| | LED Clip 5mm | 1 | (YY40T) |
| | SPST Ultra Min Toggle | 5 | (FH97F) |
| | AC Adaptor Regulated | 1 | (YB23A) |
| | ABS Console M6006 | 1 | (LH66W) |
| | BNC Round Skt 75 Ω | 2 | (FE31J) |
| | Pan Mnt Pwr Skt 2-5 | 1 | (JK10L) |
| | Self Tap Screw No.4 \times 1/4in. 1Pkt | | (FE68Y) |

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LP48C (Video Box) Price £19.95.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1992 Maplin Catalogue.

Video Box PCB Order As GE85G Price £4.95.

THURLBY LA160 LOGIC ANALYSER (WITH LE32)

GROUP A
Clock polarity= NEG Logic= NEG Trigger Word (HEX)= 0100
GROUP B
Clock polarity= POS Logic= NEG Trigger Word (MIX)= XXXXXXXX XX
COMMON
Clock enables= XX Trigger Enables = X1X
Counts = 0000
ARM = X
Arm delay = ON

32 CHANNEL MODE

GROUP B State Listing

| LOC | BINARY DATA | LOC | ASCII | MIX |
|------|------------------|------|-------|-------------|
| -002 | 0111101100000000 | -002 | {. | 01111011 00 |
| -001 | 0111101100000001 | -001 | {. | 01111011 01 |
| -000 | 1111111100000001 | -000 | .. | 11111111 01 |
| 000 | 0111101000000001 | 000 | z. | 01111010 01 |
| 001 | 0111101000111110 | 001 | z> | 01111010 3E |
| 002 | 0101111100111110 | 002 | > | 01011111 3E |
| 003 | 1101111100111110 | 003 | > | 11011111 3E |
| 004 | 0111101111111111 | 004 | {. | 01111011 FF |
| 005 | 0111101111111111 | 005 | {. | 01111011 FF |
| 006 | 1111111111111111 | 006 | .. | 11111111 FF |
| 007 | 0111101011111111 | 007 | z. | 01111010 FF |
| 008 | 0111101000110010 | 008 | z2 | 01111010 32 |
| 009 | 0101111100110010 | 009 | 2 | 01011111 32 |
| 010 | 1101111100110010 | 010 | 2 | 11011111 32 |
| 011 | 0111101111110111 | 011 | {w | 01111011 F7 |
| 012 | 0111101100000000 | 012 | {. | 01111011 00 |
| 013 | 1111111100000000 | 013 | .. | 11111111 00 |
| 014 | 0111101100000000 | 014 | {. | 01111011 00 |
| 015 | 0111101100000010 | 015 | {. | 01111011 02 |
| 016 | 1111111100000010 | 016 | .. | 11111111 02 |
| 017 | 0111111110111111 | 017 | ? | 01111111 BF |
| 018 | 0111101111111111 | 018 |). | 01111011 FF |
| 019 | 1111111111111111 | 019 | .. | 11111111 FF |
| 020 | 0111101011111111 | 020 | z. | 01111010 FF |
| 021 | 0111101000111100 | 021 | z< | 01111010 3C |
| 022 | 0101111100111100 | 022 | < | 01011111 3C |
| 023 | 1101111100111100 | 023 | < | 11011111 3C |
| 024 | 0111101010111110 | 024 | z> | 01111010 BE |
| 025 | 0111101011111111 | 025 | z. | 01111010 FF |
| 026 | 0101111111111111 | 026 | .. | 01011111 FF |
| 027 | 1101111111111111 | 027 | .. | 11011111 FF |
| 028 | 1111111111111111 | 028 | .. | 11111111 FF |
| 029 | 0111111100000001 | 029 | .. | 01111111 01 |
| 030 | 0111101000000001 | 030 |). | 01111011 01 |
| 031 | 1111111100000001 | 031 | .. | 11111111 01 |
| 032 | 0111111100000111 | 032 | .. | 01111111 07 |
| 033 | 0111101000001111 | 033 |). | 01111011 07 |
| 034 | 1111111100000111 | 034 | .. | 11111111 07 |
| 035 | 0111101000000111 | 035 | z. | 01111010 07 |

Figure 9. Thurlby 32-channel state listing.

The analyser is 'triggered' by a 16-bit word, usually an address which appears on the address bus while the program is running. This trigger word, (e.g. 0100) is loaded into the 'trigger word detector', and the program is run.

The trigger word is designated by a numeric cursor (000). The cursor can be stepped back so that, for example, 00FF has a negative cursor value (-001). Address 0100 will have 000; 0101 will have 001, and so on.

The table in Figure 3 shows displayed address, data and cursor information on the logic analyser for several cursor positions. (This particular example is actually a 6502 program listing).

A 16-channel analyser can only display address bus contents (16 bits). A further 8 channels are required to display address and data lines simultaneously. Figure 3 shows address and data information displayed on the logic analyser. Displaying 24 bus lines (using 24 channels) simultaneously requires a trigger word of 24 bits, e.g. 003402. Figure 4

shows a typical logic analyser timing diagram display on its monitor screen.

The logic analyser is used to capture the logic state of the address, data and control lines for every 'T' state, or clock cycle. The analyser will recognise a

'trigger event', and stop after a further 500 'T' states have occurred. The condition of the address, data and control lines may now be examined for the 500 'T' states preceding the 'trigger event', and for the 500 which follow it.

Figure 6 shows how the simpler, portable Thurlby LA-160 logic analyser is connected to a Z80-based microcomputer such as the Tatung Einstein. To achieve this set-up, the Z80 MPU must be carefully removed from the Einstein (or other microcomputer), ensuring that the computer and logic analyser are both switched OFF. The logic analyser 'Z80 personality module' is then plugged into the vacant processor socket. This personality module has an on-board Z80, which now becomes the system microprocessor.

Switching on the microcomputer and logic analyser, and loading (but not running) the test program already mentioned, enables logic analysis to be carried out.

A trigger word of 0100H is then set, and pressing the 'SINGLE' key on the analyser front panel allows the analyser to begin acquiring data.

Running the program via a suitable command (e.g. G, for 'go') should result in the Thurlby analyser displaying the message 'FULL'. The analyser cursor is then reset to 000, and the first seven values captured from the address, data and control lines can be noted.

At this point it is very important to understand that the data transferred to the logic analyser's memory (RAM) is not just the program itself, but a record of all address, data and control bus activity for the duration of the program execution. This information is as shown in Figure 7.

Unfortunately, an analyser such as the Thurlby provides limited display facilities, having only a seven digit, seven-segment display. This analyser, however, has an output terminal which, when fed into an oscilloscope Y input and external trigger sockets as shown in Figure 8, produces a 16-channel display, albeit a pseudo timing-diagram screen display.

However, a more useful and complete logic analyser listing can be provided by connecting the Thurlby to a printer, via its RS-232 serial port. An

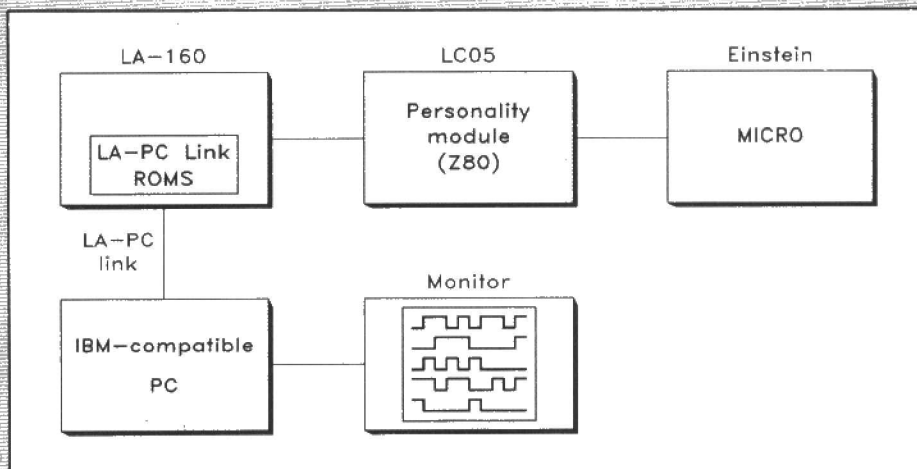


Figure 10. Connection of LA-160 to IBM PC, to provide monitor screen display.

THURLBY LA160 / LA-PC LINK TIMING DIAGRAM

Current data buffer: DY/2K*16 Time: 10 : 10 Date: 21 /9 /1991
 Acquisition title: Untitled.....
 Description:

Acquisition parameters:

CLOCK:

source = INT period = 2 uS logic = NEG enables = 11 polarity = XXX

TRIGGER:

word = 1X0X 0X10 11XX 0XXX

hold-off = OFF

enables = 1111

count = 9422

arm = 0

arm delay = ON

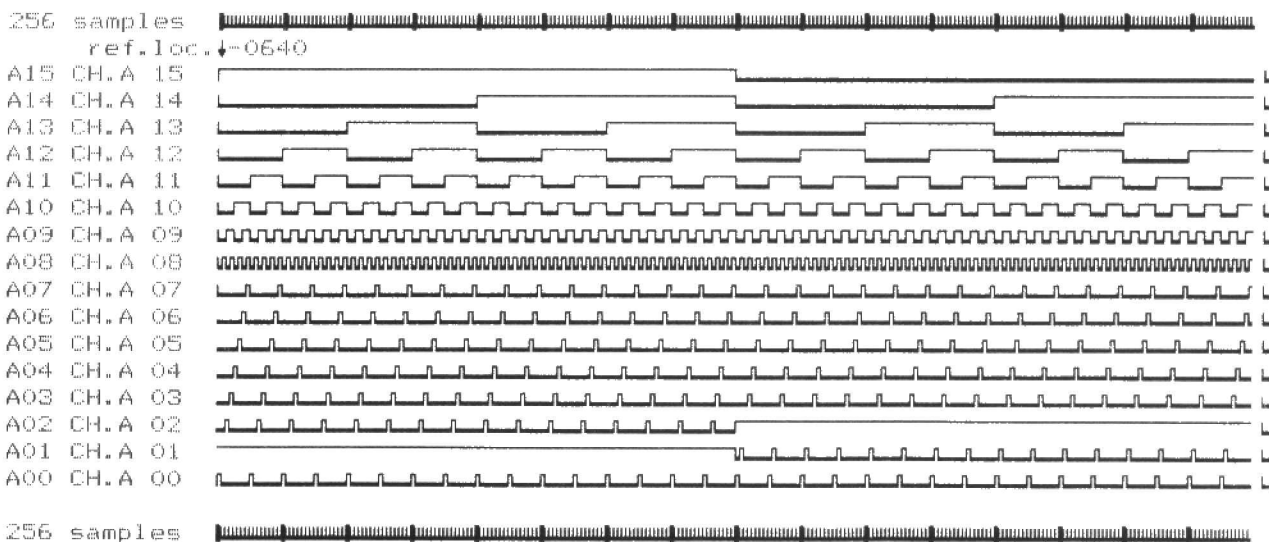


Figure 11. Thurlby LA-160/LA-PC Link timing diagram printout.

example of the printout generated by such an arrangement is shown in Figure 9. This provides data in binary form (16 bits) and individual control bits 'MIX', alongside recognisable hex codes 01, 3E, FF, etc. in the right hand column, which correspond to the disassembled listing of Figure 7.

This format is not particularly easy to use or decipher, but a significant improvement on this can be achieved by connecting up the Thurlby to an IBM-compatible PC, via the appropriate software modification and cable (see Figure 10).

This modification enables a true timing diagram display to be produced on the PC screen. This is more like the conventional (industrial standard) screen display shown in Figure 4. Also, this display can be easily dumped to a printer from the PC (see Figure 11).

The more expensive and sophisticated industrial-quality logic analyser provides timing diagram displays at various magnifications, state listings, and menu-driven facilities for setting logic thresholds, clock sampling rates, etc. Such an analyser is more flexible, can be used with any digital system, and has individual probe clips for connection to any circuit node.

The Signature Analyser

A signature analyser is also a very specialised piece of test equipment, not normally to be found in a repair workshop or college laboratory. It is designed to be used in conjunction with a specific product such as, for example, a microprocessor-controlled automobile diagnostic machine. The 'signature' is a group of bits which are obtained from a digital circuit node when a specific activity, such as a 'free running' test, is being carried out. For example, if a continuous loop of NOP (no operation) instructions were being fetched and executed by the microprocessor system under test, precise signatures would be expected at each node in the circuit. Signature tables are provided by the manufacturer, and the signature analyser and probe (normally produced by the same product manufacturer) are used to verify correct signatures. A signature analyser is ideally suited for work on mass-production microprocessor systems, or to help with high-volume repairs of a single product line.

Summary

Parts 1 to 4 have covered most of the hardware aspects of microcomputer test-

ing and fault-finding, apart from printers and IBM-type PCs utilising 16-bit and 32-bit MPUs. Printers are a subject in themselves, and although their basic operation may be appreciated via the material in Part 2 on input/output devices, they require a more detailed and lengthy treatment, which is beyond the scope of this series. Similarly, the IBM-compatible PC represents a different type of equipment in terms of fault-finding and repair, not least because of its highly modular design and tendency towards 'throw-away' modules. Fault-finding at component level is becoming both more complex and less economical. Again, a more comprehensive treatment of this area is required – and may be the subject of a separate series.

Next Month

The final part of the series will cover software, where relevant to fault-finding. This includes the use of operating systems, the use of disc storage, as well as the use of different utility programs, machine code, assembly language and high-level programming languages to provide software testing as an aid to hardware fault-finding.

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